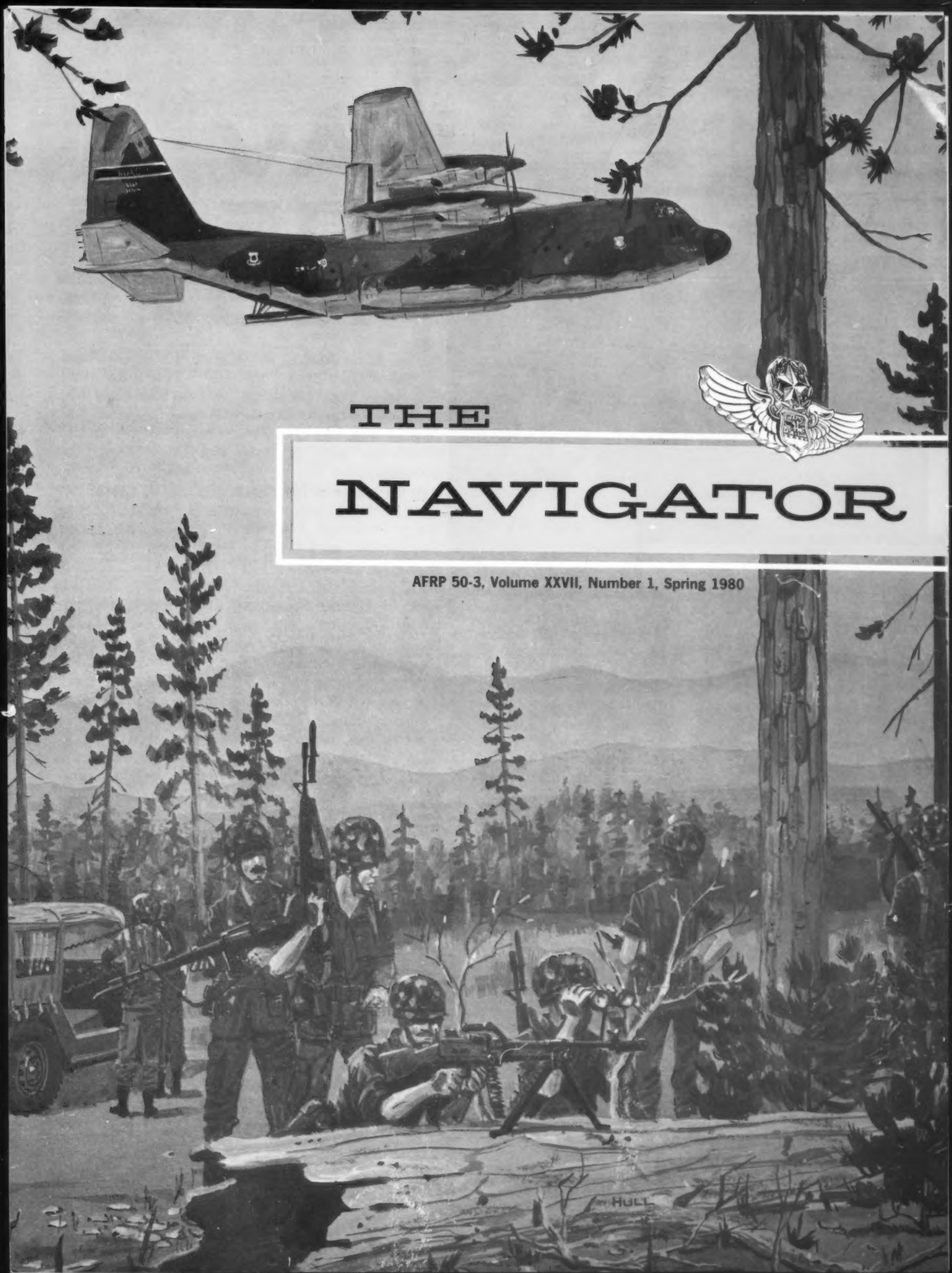
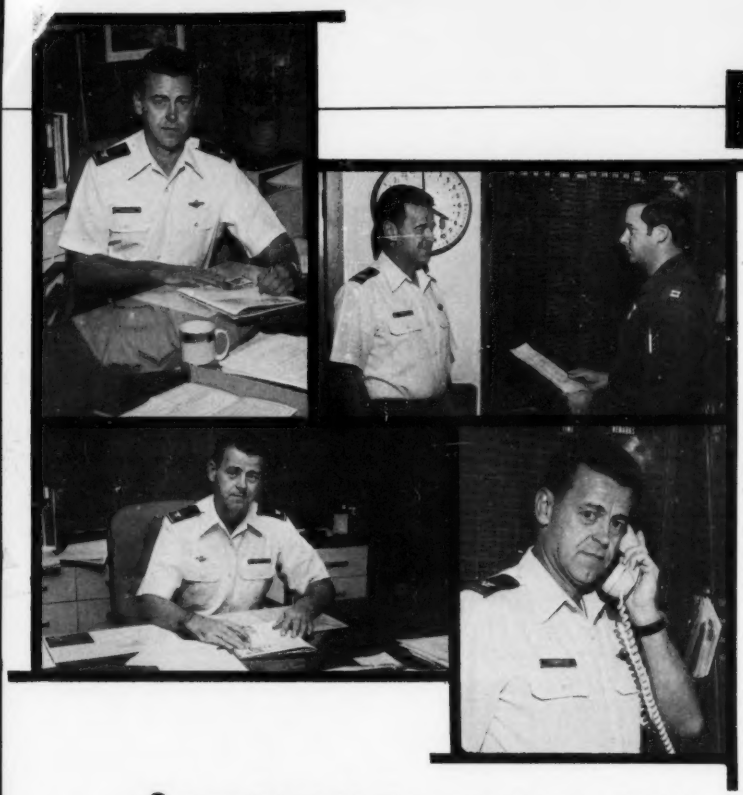


THE NAVIGATOR

AFRP 50-3, Volume XXVII, Number 1, Spring 1980



NAV OF NOTE

Colonel Robert M. Thompson became Deputy Commander for Operations, 323d Flying Training Wing, Mather AFB, California, on 1 June 1979.

Born in Haverhill, Massachusetts, Colonel Thompson graduated from the University of Massachusetts in 1957 with a degree in Economics and was commissioned as a second lieutenant through AFROTC. He began active duty in May 1958, entering navigator training at James Connally AFB, Texas. He later completed Navigator Bombardier Training at Mather in 1960 and was retained as an NBT instructor.

In 1961, he was assigned as a B-66 navigator with the 47th Bombardment Wing, RAF Sculthorpe, United Kingdom. The following year, he was selected as a RB-57D reconnaissance systems operator at Rhein Main AB, Germany and remained in this highly demanding, unique, and exciting assignment until June 1965.

Returning to the United States, he completed his master's degree in Aerospace Management at the University of Southern California. In February 1966, Colonel Thompson arrived at Mather as an Undergraduate Navigator Training (UNT) instructor. During this assignment, he accepted the course curriculum development duties for the entire UNT program.

As the Vietnam war escalated, Colonel Thompson's reconnaissance background came into demand. He completed RF-4C training at Mountain Home AFB, Idaho, in August 1969 and was immediately sent to the 12th Tactical Reconnaissance Squadron at Tan Son Nhut AB, Vietnam. During his one-year tour he flew 186 combat missions and, though relatively new to the RF-4C, he also became the Wing Stan/Eval navigator.

At the close of his SEA tour, Colonel Thompson was selected to become a Systems Project Officer at Wright-Patterson AFB, Ohio; however, his broad operational background made him a prime candidate for the F-111 vanguard in Europe. Consequently, his orders were changed to the 79th Tactical Fighter Squadron, RAF Upper Heyford, United Kingdom. His extensive reconnaissance background was quickly recognized and exploited. He became a Squadron Radar Strike Officer and was later selected as Chief, Radar Strike section.

He easily took the next step as an action officer in the Radar Systems Division for the Deputy Chief of Staff for Operations and Intelligence, HQ USAFE. In this capacity, he was responsible for the development of low level flying as well as radar bomb site procedures for the entire European theater. During this one-year headquarters tour, Colonel Thompson significantly improved morale at the radar bomb sites through frequent visits to the facilities and by briefing personnel on procedures and the reasons behind them. In addition, he augmented the USAFE IG team during Operational Readiness Inspections.

Colonel Thompson returned to Mather in July 1974. Achieving many of his career goals, he served as: Operations Officer, 452d Flying Training Squadron; Chief, Training Division; Chief, Stan/Eval Division; Commander, 451st Flying Training Squadron; and Deputy Base Commander.

During this tour, Colonel Thompson was promoted to colonel below-the-zone. As such, he was also selected to attend the Air War College at Maxwell AFB, Alabama, in June 1978.

Upon graduation in May 1979, he achieved another of his career goals by returning to Mather as the Deputy Commander for Operations. In this

capacity, Colonel Thompson supervises the conduct and quality of navigator training for all US military services. In addition to training US Air Force, Navy and Marine navigators he is also responsible for training navigators from many allied nations. His training force consists of seven flying squadrons and five divisions. This complex not only conducts Undergraduate Navigator Training, but also training for Navigator–Bombardiers, Electronic Warfare Officers, Pilot Instructors and, of course, Navigator Instructors. In addition, follow-on training is provided in Tactical Navigation and Advanced Navigation.

Colonel Thompson has not changed his career goals since he was a second lieutenant and has already achieved many of them. His next goal is to be a Wing Commander. He believes strongly in the "fly and fight" mission of the Air Force. Consequently, he desires to remain in operations and be an integral part of the primary mission of flying—whether in training or combat. His extensive operational background certainly supports this belief.

Concerning the current navigator retention issue, Colonel Thompson had these interesting comments, "I believe the single reason for the retention problem is the lack of fair pay. We cannot deny the younger people the pay that others in civilian life are receiving. Our people will work for less, but they must be able to make a decent living and keep up with inflation." He also feels that, "the navigator retention problem would lessen if navigators were given an opportunity to fly in more than one aircraft. There is a definite, rewarding future for navigators in the service."

His basic philosophy is simple, yet challenging: "Be the best at the job you are presently doing—whatever it may be. Maintain a positive, open attitude and constantly strive for excellence without expecting immediate reward. Young officers' only limitations are those they set for themselves."

TO THE EDITOR

Dear Editor

I offer some comments on two articles from the Winter 1979 edition of THE NAVIGATOR—"Navigator Management" by Lt Col Willette and "The Score." While the numbers associated with navigator flying command opportunities reflect positive action in equal opportunity, those numbers pertaining to other flying commands, particularly MAC and SAC, indicate almost no willingness to place outstanding navigators in command positions. Air Force wide, the number of flying command slots filled by navigators is virtually unchanged since September 1978.

That the lack of opportunity for advancement is creating low morale in MAC and SAC was confirmed by MAC and SAC squadron commanders at the Squadron Commanders Symposium held at AFMPC 14-16 November 1979. And why not? Statistics provided by MPC to at least one panel of commanders at the Symposium showed that on the last O-5 promotion board, O-4s performing navigator duties (vice rated supplement duties) had a primary zone promotion rate of less than 33 percent; pilots in the same category had a success rate greater than 66 percent. These figures clearly point out that despite the repeal of Title 10 and AF Chief of Staff direction to the contrary, navigators in some commands are still treated as "second-class citizens." If you believe there just aren't any navigators with the background and experience for command (I obviously don't), then you probably agree that unless navigators are afforded the opportunity to gain that initial experience as flight commanders, command opportunities will never exist for navigators.

As a four star general recently said at the Academy, command opportunities for navigators will not improve until the general officers of his vintage have retired. The general stated that when he was a young officer, 99 percent of the officers were pilots and the other 1 percent couldn't qualify; therefore, in the back of the mind of an officer of that vintage, nonpilots were, and are, inferior.

If a senior officer wishes to preclude flying commands for navigators, that individual can manufacture numerous logical-sounding excuses. On the other hand, if that officer wishes to assign command positions on an unbiased, best qualified basis, there are numerous competitive navigators available. The question is not one of "timing," or a lack of qualified navigators. The question is one of equal opportunity and better use of the leadership and management talents available. The end product will be a better Air Force.

WILLIAM H. BUTLER, Lt Col, USAF
Chief, Aviation Science Division
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USAF Academy CO 80840

AFRP 50-3, Volume XXVII, Number 1, Spring 1980

Department of the Air Force

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Perhaps the C-130 navigator in our action cover has just employed the technique suggested in "Wind Circle Airdrops - A Different Approach" on page 8.

What's it like to be an Air Force navigator? Be sure to read "Last Flight" on page 28.

Distribution: One copy per two navigators.

SCRAMBLE!

Captain Gary A. LEWIS
429 TFS
Nellis AFB, NV

A voice on the tactical radio in our aircrew lounge suddenly squawks, **"526, SCRAMBLE TWO FOX-4s, PRIORITY ONE!"** And the frantic rush is on! Throwing away my magazine, I dash headlong to the fireman's pole. We all arrive simultaneously, but three of us stand by in excited impatience while the first man scurries down. Then, one at a time, the rest of us slide down to the ground floor of the alert building and burst through the doors to our waiting airplanes. Shrill radio transmissions add to the general clamor and tumult and the dull blast of the scramble horn echoes even louder as we sprint through the alert barn to our armed and ready F-4E fighters. Another air defense scramble is in progress!

The pilot and I race into the alert hangar and clamber up the side of our Phantom. I jump, feet first, onto the rear cockpit seat, then sit down. The aircraft stopwatch is punched to record our scramble time. The shoulder harness is already in the cockpit, partially hooked up, and I quickly start the strap-in routine: right arm into the harness...pull it snug...twist and stretch the left arm back and forth until the harness is over my shoulder; now the lock connecting the left and right harnesses can be snapped closed...quickly grab the cloth skull cap from the radar scope and put it on...pick up the helmet resting on the canopy rail and slide it on over the skull cap...snap the rubber oxygen mask over my face. The mask is cold, like wet iron, momentarily numbing my skin.

Our crew chief throws the ejection seat pins into my lap like a hot potato—does the same for the pilot—and then leaps down, ready for a launch.

Suddenly, the green launch light glows brightly on the alert hangar ceiling! This one's not a practice drill—IT'S THE REAL THING! I immediately switch to 100% oxygen as the pilot starts the Phantom's two powerful J-79 engines. A blue starter cartridge fog momentarily shrouds the wings and eddies around the engine intakes, stinging my eyes and nose. The acrid smell is reminiscent of a freshly fired cap gun. When both J-79s are up and ready, I switch the Inertial Navigation System (INS) into Align mode and turn on the radar to check the built-in tests. While the radar is warming up, I quickly fasten the four ejection seat leg straps. Less than 90 seconds have passed! The time is important because our two fighters must be airborne as soon as possible to intercept the unknown target. A matter of minutes could be the difference between a successful or missed intercept against an attacking enemy.

My left thumb engages the radio microphone switch, "Lima Mike Zero One, check!" The other Weapons System Officer responds, "Two," laconically, as if this was another routine training mission. The command post is up on our frequency relaying instructions. I copy the message, acknowledge receipt, then switch the flight over to Tower frequency.

As Tower clears us for a high speed taxi, I cinch my seatbelt down tightly, check all my other seat connections, and switch the INS from Align to Navigate. The Alert Scramble checklist is completed as we blow out of the alert hangar. Our canopies are lowered as Tower gives us takeoff clearance. All other traffic is held to expedite departure for our top priority mission.

We quickly finish our abbreviated pre-takeoff checks, and a glance at my watch reveals only a few minutes have elapsed since being interrupted by the scramble horn.

The pilot slams the throttles to afterburner, and we immediately begin our takeoff roll. The airspeed indicator rapidly moves to 80 knots, then 130 knots...all systems are "GO." More than 25 tons of fuel and metal swiftly spring into the air! Within seconds, the gear and flaps are up.

The acceleration throws me back against the seat as our climb rate increases to more than 6,000 feet per minute. We knife through the clouds and contact Departure Control on UHF. Departure gives us a radar vector, and we bank hard right directly toward the West German Buffer Zone (BZ). The BZ is an artifical flying zone, around 25 nm wide near the political border, designed to prevent aircraft from accidently penetrating Warsaw Pact airspace.

Our wingman remains some distance behind us in radar trail formation because the weather is solid instrument conditions. During climbout, we check and test all our weapon systems. The four radar-guided AIM-7 Sparrow missiles are tuned and ready, plus we have four AIM-9 Sidewinder infrared missiles, and the 20mm internal cannon. Our weapons may be needed if the unidentified target turns out to be hostile.

Abruptly, we emerge into an azure blue sky bright with sunlight. I stare, in a momentary hypnosis, over the contrast between the two worlds of ground and air. The temporary paralysis ends when Departure Control gives us a frequency change to a Ground Controlled Intercept (GCI) site. Our wingman rejoins as we contact the GCI controller.

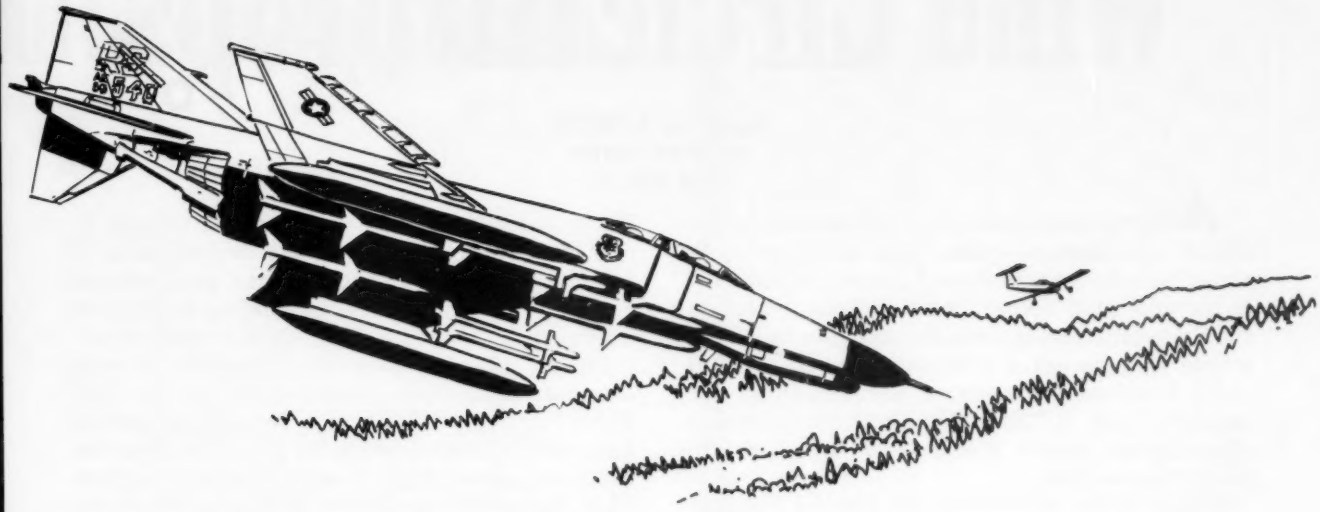
GCI vectors us towards the Buffer Zone with sharp, staccato commands. Our target is an unknown, but friendly, aircraft in the BZ without a flight plan. The ground controller also tells us that he has not been able to gain radio contact with the target aircraft. We drone without course changes for several minutes, with GCI punctuating the silence with periodic updates on our target's location.

The target's altitude is 1,000-2,000 feet, with a speed of about 100 knots, according to the GCI controller. The pilot asks for a descent, and GCI clears us down to 2,000 feet above the ground. Fortunately, the weather in this part of Germany is bright and sunny, and we're able to maintain visual conditions during the descent.

GCI instructs us to identify the aircraft type and nationality. We repeat the instructions, and the controller then furnishes us with the target's approximate bearing and range. I fine tune the radar with receiver gain and contrast controls, and position the radar antenna elevation strobe for the target's estimated altitude.

Now, the target is on our nose for 15 miles on a reciprocal heading. We bank away slightly to offset for a stern conversion intercept. At 10 miles, I have a radar contact, and give the pilot a constant, precise flow of information on the target's position. Using my directions, he scans that airspace and calls a "TALLYHO!" The target has been sighted.

We maneuver to the target's stern while our supporting wingman moves to trail position. With our flaps lowered, we slow down as much as possible, weaving behind and above the target to keep it in sight. We close in just enough to observe the aircraft tail markings. It's a civilian, single-engine type aircraft.



As we circle for another ID pass, the target aircraft lands at a small grass airfield. From our charts, we determine the airfield name and report the intercept results to GCI. The controller acknowledges our information, and clears us to return to home base. The information will, in turn, be relayed to the civil air authorities for further investigation.

Then, the pilot shoves the throttles forward, and effortlessly raises the Phantom's nose. We climb rapidly, and bank the airplane for a course to "home plate," Ramstein. Our wingman rejoins as GCI gives us vectors out of the BZ. We must get back on alert as quickly as possible.

Minutes later, Approach Control clears us direct to the initial approach fix. I call our command post to report the maintenance status of each Phantom. Then, we slide down the TACAN penetration and coast into the field on a precision approach.

On our landing rollout, I check the cockpit's rear view mirrors for an open drag chute. We slow to an easy roll and turn off the active. The pilot dumps the chute in the grass near the taxiway edge, and we run through the after-landing checks.

The aircraft is halted on the alert taxiway, allowing the maintenance crews to safety pin the missiles, and safe-up the nose gun prior to the refueling operation. After de-arming, we taxi to the parking apron in front of the alert hangar and shut down. The thunderous din subsides as the fighter's powerful engines spool down. Maintenance crews swarm over the planes to hasten their return to alert status.

After several thousand pounds of JP-4 are pumped into the fuel tanks, the Phantoms are stuffed back into their hangars. I realign the Inertial and set up the cockpit switches. As before, my shoulder harness stays in the cockpit, along with checklists and maps. The fighters are now "cocked" for the next scramble. I pause briefly behind the now mute Phantom feeling the heat from the rapidly cooling engines. I relive the scramble excitement of an hour ago and am ready to go again.

Back in the aircrew lounge, we critique all aspects of the mission. Our discussions center on avoiding mistakes in a hostile situation. Even though many scrambles never go beyond engine start, aircrew readiness is still paramount. Another scramble, perhaps against enemy fighters, could be just a few seconds away, beginning with a voice asking for two FOX-4s.

A 1969 graduate of the University of Virginia, Capt Lewis has a master's degree in Systems Management from the University of Southern California. After UNT and F-4 RTU, he was assigned to Osan AB, followed by duty at Ramstein AB with the 86 Tac Ftr Gp. Assigned to the 429 Tac Ftr Sq, Nellis AFB, Capt Lewis now attends the USAF Fighter Weapons School.

Wind Circle Airdrops - A

Major Jay A. WEISS
HQ MAC/DOVN
Scott AFB, IL

Airdrop operations are a critical part of the USAF navigator's trade, and proficiency in visual techniques remains an important asset for those who must accomplish the airdrop mission should sophisticated, complicated aids fail. This article will discuss a different way to use wind circle solutions in resolving the Computed Air Releast Point (CARP). The method discussed offers quick, simple construction and easy in-flight computation.

MACR 55-40, *Computed Air Release Systems Procedures,* contains instructions for constructing a basic wind circle and completing MAC Form 512, *Computed Air Release Point Computations.* Item 19 of the form, "Total Time of Fall," yields a wind circle size from the following formula:

$$\frac{\text{Wind Speed}}{1.78} = \frac{\text{Drift Effect}}{\text{Total Time of Fall}}$$

$$\frac{10}{1.78} = \frac{219 \text{ Yards}}{38.9 \text{ (TTF)}}$$

Using the sample drop zone diagram (Figure 1), center the wind circles on the desired point of impact and draw in azimuth lines, also centered on the point of impact. Any wind up to 40 knots may now be plotted directly on the wind circle.

During mission planning, compute forward travel distances using formula "G" on the MAC Form 512 (Figure 2). Forward travel distances for appropriate groundspeeds are plotted in the lower left-hand corner of the sample drop zone diagram. This allows the navigator to mark a wind and adjust for forward travel throw in only a few seconds.

If the navigator has drift and groundspeed information inbound to the drop zone, he can plot wind another way using head wind and tail wind components. A true airspeed of 130 knots, for example, yields approximately 4 ½ knots of crosswind component for each 2 degrees of drift. Appropriate crosswind values are found in the adjacent box. A comparison of true airspeed/groundspeed values will give a

Different Approach

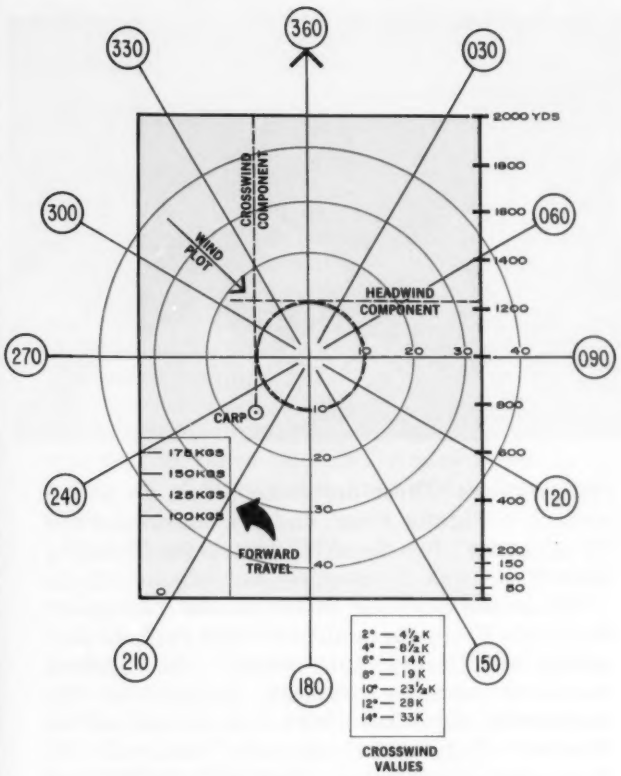
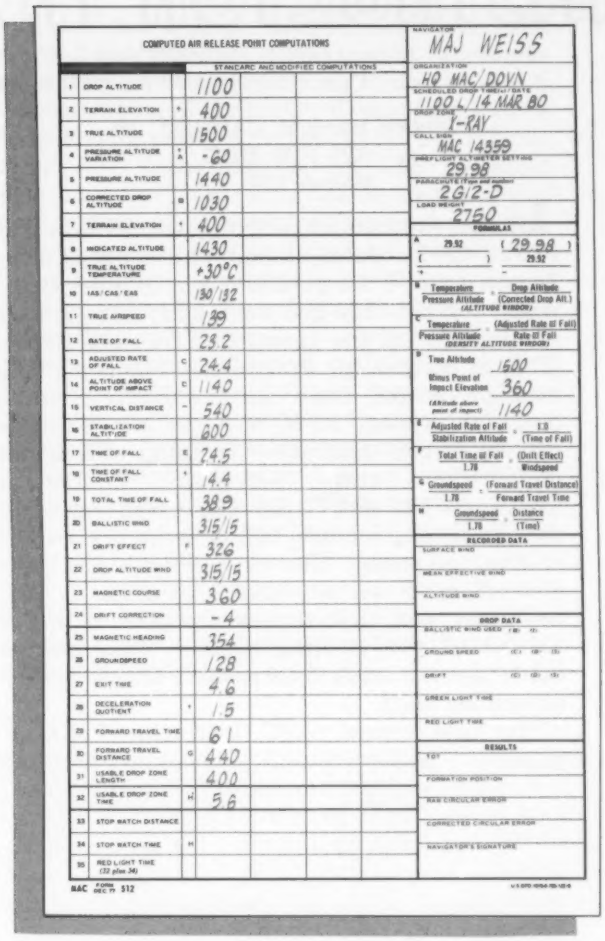


Figure 1

WIND CIRCLE DROP ZONE DIAGRAM



COMPUTED AIR RELEASE POINT COMPUTATIONS

			STANDARD AND MODIFIED COMPUTATIONS			
1	DROP ALTITUDE		1100			
2	TERRAIN ELEVATION	+	400			
3	TRUE ALTITUDE		1500			
4	PRESSURE ALTITUDE VARIATION	+ −	-60			
5	PRESSURE ALTITUDE		1440			
6	CORRECTED DROP ALTITUDE	B	1030			
7	TERRAIN ELEVATION	+	400			
8	INDICATED ALTITUDE		1430			
9	TRUE ALTITUDE TEMPERATURE		+30°C			
10	IAS / CAS / EAS		130/132			
11	TRUE AIRSPEED		139			
12	RATE OF FALL		23.2			
13	ADJUSTED RATE OF FALL	C	24.4			
14	ALTITUDE ABOVE POINT OF IMPACT	D	1140			
15	VERTICAL DISTANCE	−	540			
16	STABILIZATION ALTITUDE		600			
17	TIME OF FALL	E	24.5			
18	TIME OF FALL CONSTANT	÷	1.4			
19	TOTAL TIME OF FALL		38.9			
20	BALLISTIC WIND		315/15			
21	DRIFT EFFECT	F	326			
22	DROP ALTITUDE WIND		315/15			
23	MAGNETIC COURSE		360			
24	DRIFT CORRECTION		-4			
25	MAGNETIC HEADING		356			
26	GROUNDSPEED		128			
27	EXIT TIME		4.6			
28	DECELERATION QUOTIENT	÷	1.5			
29	FORWARD TRAVEL TIME		6.1			
30	FORWARD TRAVEL DISTANCE	G	440			
31	USABLE DROP ZONE LENGTH		400			
32	USABLE DROP ZONE TIME	H	5.6			
33	STOP WATCH DISTANCE					
34	STOP WATCH TIME	H				
35	RED LIGHT TIME (32 plus 34)					

NAVIGATOR: MAJ WEISS
ORGANIZATION: HQ MAC/DOVN
SCHEDULED DROP TIME/DATE: 1100 L/14 MAR 80
DROP ZONE: T-RAY
CALL SIGN: MAC 14359
PREFLIGHT ALTIMETER SETTING: 29.98
PARACHUTE TYPE and number: 2G12-D
LOAD WEIGHT: 2750

FORMULAS

A: 29.52 (29.98) / ( ) 29.52 + −

B: Temperature / Pressure Altitude = Drop Altitude (Corrected Drop Alt.) (ALTITUDE WINDOW)

C: Temperature / Pressure Altitude = (Adjusted Rate of Fall) Rate of Fall (DENSITY ALTITUDE WINDOW)

D: True Altitude 1500 Minus Point of Impact Elevation 360 (Altitude above point of impact) 1140

E: Adjusted Rate of Fall / Stabilization Altitude = 1.0 / (Time of Fall)

F: Total Time of Fall / 1.78 = (Drift Effect) / Windspeed

G: Groundspeed / 1.78 = (Forward Travel Distance) / Forward Travel Time

H: Groundspeed / 1.78 = Distance / (Time)

RECORDED DATA
SURFACE WIND
MEAN EFFECTIVE WIND
ALTITUDE WIND

DROP DATA
BALLISTIC WIND USED (1) (2)
GROUND SPEED (1) (2) (3)
DRIFT (1) (2) (3)
GREEN LIGHT TIME
RED LIGHT TIME

RESULTS
TOT
FORMATION POSITION
MAN CIRCULAR ERROR
CORRECTED CIRCULAR ERROR
NAVIGATOR'S SIGNATURE

MAC FORM DEC 71 512

Figure 2

COMPUTED AIR RELEASE POINT COMPUTATIONS

head/tail wind component. An in-flight true airspeed of 134 kts, a groundspeed of 123 kts, and a drift of 5° right, for example, would give 11 ½ knots of head wind component. Plot the crosswind component parallel to the drop zone axis and the head wind component perpendicular to the axis. The intersection of these two lines gives a wind of 315/15. Apply forward travel vector and you now have a CARP.

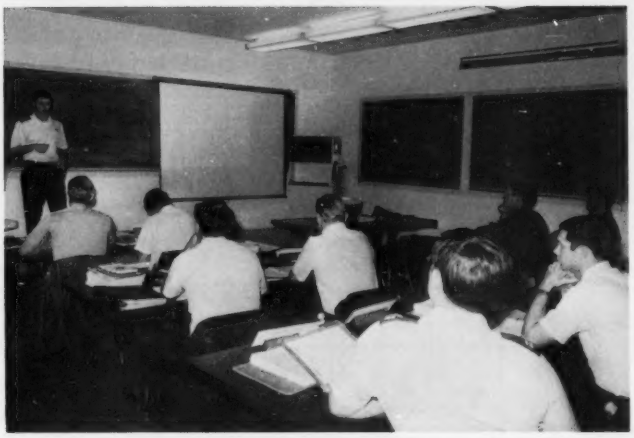
From this point, it is a simple matter to compute timing or observe visual release points. The difficult part, determining CARP location, is accomplished with the drop zone diagram plus a few circles and lines. This method allows the navigator to make a reliable visual drop, adjust for last minute wind shifts, and also compensate for malfunctions in automatic drop systems.

Maj Weiss has a master's degree in Political Science. After UNT, he was assigned to the C-130 in the Philippines before instructor duty at Forbes AFB. At Little Rock AFB, he served in Stan/Eval and then as Tactics Officer. Maj Weiss now is an Evaluator in Stan/Eval, HQ MAC, Scott AFB.

INSTRUCTOR TRAINING SCHOOL...

"Having learned, I am ready to teach"

Captain Harry M. CALCUTT, JR.
323 FTW/DOTI
Mather AFB, CA



In ancient times when flying was done only by Icarus and Daedalus, Roman philosopher Lucius Seneca said, "I am glad to learn, in order that I might teach." This quotation aptly paraphrases the mission of the Instructor Training School (ITS) at Mather Air Force Base. ITS is a flying training school listed in the USAF Formal Schools Catalog, AFM 50-5, as two separate courses: "ATC Instructor Training—Navigator (B-V7D-D)" and "Navigator Instructor Training—T-43 (B-V7D-E)." Compared with other flying training schools, ITS is perhaps the most unique, preparing the new arrival for three distinct roles: an academic instructor, a T-43 navigator, and an instructor navigator in one or several of five training courses. This process takes approximately three months and requires a diversified staff.

The first course, ATC Instructor Training, qualifies personnel as academic training instructors in flying or related training programs. Course duration is 13 training days with 32 hours of "Instructional Methodology" (which certainly sounds impressive), 33 hours of lesson preparation, and 34 hours of classroom presentations. Each student, of course, does not give 34 hours of speeches in 13 short training days—he will also listen to and critique the presentations of his classmates. The 32 hours of "Instructional Methodology" consist of instructional blocks on Methods of Instruction, Evaluation, Counseling, Student-Instructor Relationships, the Learning Process, etc. The ITS graduate has a basic knowledge of various instructional techniques. He is also familiar with Mather's format of instruction and the visual aid tools used in the classroom. To build the new instructor's confidence, he gives six practice presentations during the Instructor Training Course. These presentations range in length from 7 to 50 minutes and cover diverse subjects. Many ITS students elect to give presentations on previous weapon systems or navigation procedures; however, others prefer to instruct in more exotic areas: "How to Win at Blackjack," "Waxing Skis," etc. The first four presentations are before other students in the class; however, the real test of abilities comes on the last two presentations. These are given before an actual student navigator class, and are considered the "final exam" for the ATC Instructor Training Course

The initial training phase in the Navigator Instructor Course is qualification in the T-43 as a navigator. During this phase, the student instructor receives training tailored to his assignment at Mather. One course is designed for Mission Support navigators assigned to Navigator - Bombardier Training (NBT) and Electronic Warfare Training (EWT). Another course is designed for Primary Mission navigators assigned to Undergraduate Navigator Training (UNT).

The Mission Support course consists of two weeks of academics, four practice flights in the T- 43, and culminates in an AFR 60-1 check ride. The academics focus on basic navigation procedures: radar scope interpretation, celestial, DR computer, and log/chart work. Following academics, the students receive practice rides in the T-43 "Max Position," under the supervision of a mission support T-43 Instructor Navigator (IN). The term "Max Position" is somewhat misleading in that it has minimal navigation equipment: VOR, radar, sextant, BDHI, and basic aircraft instruments. When a student is deemed ready, he flies an AFR 60-1 check ride during which he obtains at least three radar fixes and two celestial fixes. Check rides are flown on standard UNT routes, usually taking five hours.

The Primary Mission course is somewhat different since these students must be familiar with all T-43 navigation equipment. This course requires approximately 5 weeks of training: 2½ weeks of academics, 3 missions in the T45 simulator, 3 missions in the T-43, and an AFR 60-1 check ride. The objective is to teach use of the T-43 equipment and UNT procedures, not navigation per se. ITS students often encounter two major problems: (1) many are not experienced in integrating the variety of equipment available in the T-43 (Inertial Navigation System, Navigation Computer System, Radar, Doppler, Sextant, Loran C, TACAN, VOR, Radar Altimeter, and basic navigation instruments); and (2) they are not familiar with the unique crew coordination factors of the T-43. These problems arise because T-43 procedures are designed for students with neophyte navigation skills, and 10-12 student navigators fly on one aircraft. The qualification phase for Primary Mission navigators also terminates in an AFR 60-1 check ride and is flown on UNT routes requiring a minimum of three radar fixes and two celestial fixes.

The examinee is also expected to integrate all equipment and keep it updated. Another feature of the AFR 60-1 check at Mather is the question and answer period (referred to as Q and A or question and silence!) between the flight examiner and the examinee at the end of each check. The Q and A applies to all navigators and includes questions on emergency procedures, equipment and local mission knowledge.

The second, and perhaps most challenging phase of the Navigator Instructor Course, is the instructor qualification phase. Over half of the ITS students have had previous instructor experience in the field, but they soon learn there is considerable difference between instructing qualified navigators and student navigators. As in the initial qualification phase, the training is tailored to the ITS student instructor's assignment at Mather: UNT, NBT, or EWT. In all cases, the required training takes approximately five weeks.

The prospective UNT instructor will have one week of academics before he starts to fly and "sim" with students. Academics provide the background necessary for instructing in the aircraft and simulator, and include information on the UNT Grading Guide, global, grid and low level procedures, as well as using the T45 simulator as an instructional tool. With this knowledge, the instructor is ready to face UNT students. An average student instructor will receive 3 sim missions, 1 Navigation Procedures Laboratory (a Dead Reckoning Trainer), and 6 T-43 instructional flights. On all missions, the ITS student will actually instruct UNT students, under the supervision of an ITS Checkout Instructor. Each squadron has its own cadre of these instructors, selected for their job knowledge, experience level, and performance. They insure that the student instructor receives guidance in mission management, instruction/evaluation, and grading, in addition to insuring that the UNT students receive appropriate training. A student IN will fly with several different instructors, thus providing a broad cross-section of training techniques. He will also fly, sim, and instruct two to four students on each type of instructional mission flown at Mather. These include Basic Navigation (Avionics), Day Celestial, Night Celestial, Low Level, and Advanced Navigation (Global/Grid). ITS training includes both the sim and T-43, because mission management in the simulator is quite different from that in the T-43. After being "certified" ready for his check by an

T45 Simulator

T-43 Navigation Training

ITS Checkout Instructor, the ITS student will be scheduled for an evaluation, as prescribed by Air Training Command Regulation 60-2. He normally selects the type of UNT mission he would like to fly for this check.

An NBT instructor does not instruct students in the aircraft. Instead, his realm of student instruction is the T10 ground trainer. Depending on his experience, a prospective NBT instructor specializes in the ASQ-48 system (B-52D) or the ASQ-38 (B-52G/H). To prepare an ITS student instructor for these specialties requires approximately 50 hours of academic instruction, centering on Mather checklist techniques and procedures and using the T10 simulator. The T10 profile encompasses all B-52 mission phases from Preflight through After Landing. This instruction is accomplished by an ITS Checkout Instructor from the NBT Squadron. ITS students specializing in the ASQ-48 system receive 14 practice simulator missions, whereas those in the ASQ-38 system receive 17. All of these simulator missions are based on the monitor/instruct concept and encompass both high and low level profiles. The ITS student monitors the first half of the mission and instructs during the second half. In addition, ASQ-38 instructors are exposed to the Short Range Attack Missile (SRAM) profile. The ITS student's training culminates in an ATCR 60-2 evaluation conducted in the T10 simulator.

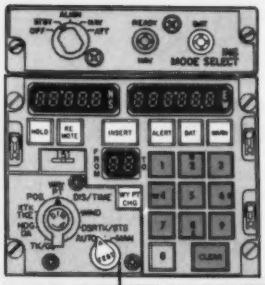
T10 (B-52G/H) Simulator Training

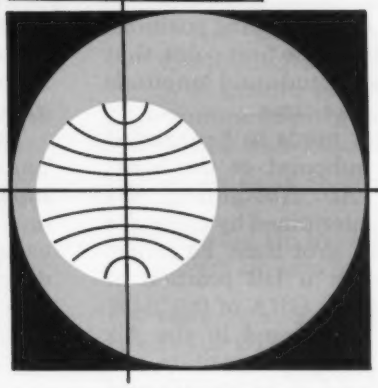
The EWT Instructor qualification is very similar in structure to the NBT qualification course. EWT instructors also accomplish all of their student instruction in simulators. Depending upon their operational background, the ITS student follows one of three areas of training: Penetration Systems (B-52), Reconnaissance Systems (RC-135), or Tactical Systems (F-105G). Each course layout is basically the same and includes approximately 30 hours of academic instruction on the equipment and procedures taught in each particular phase. The ITS student receives most of this instruction by monitoring EWT student classes. The number and type of simulator missions vary with the different areas of training. In Penetration Systems, he instructs and evaluates five practice missions in the AN/ALQ-T4, working one-on-one with an EWT student. For both Reconnaissance and Tactical Systems, the student instructor receives four practice missions in the AN/ALQ-T5 Simulator. In the T5 each instructor works with four students, each flying his own mission at his own speed. The primary duty of the T5 instructor is to instruct, assist, and critique the student, since the simulator does all of the evaluation. The ITS student also works under the supervision of a squadron ITS Checkout Instructor. His training culminates with an ATCR 60-2 instructor check in the appropriate simulator.

Regardless of a prospective instructor's background, the end result is the same. In three months he gains the required knowledge to become an academic platform instructor, a T-43 navigator, and an IN in one of the systems at Mather. Having learned, the ITS student is now ready to teach.

T4 EW Simulator

Capt Calcutt graduated from the USAF Academy with a degree in Electrical Engineering. Following UNT and EWT, he was assigned to Blytheville AFB as a Wing Stan/Eval EWO. He has served at Mather AFB for the past three years as a UNT Instructor, a Curriculum Manager, and a Wing ITS Instructor. Capt Calcutt recently has been selected for graduate school attendance thru AFIT.





OMEGA and INS precomps

Captain Glon S. "Tech" TURNER
Defense Logistics Agency/DCASPRO, Hayes
Birmingham, AL

"Don't worry why or even how it works—it just does," explained my celestial instructor. I remember the confusion in my mind trying to grasp all of the concepts just explained about celestial theory: NADIR, Zn, SUBPOINT, CO-ALTITUDE, ASTRONOMICAL TRIANGLE, and so on. Alas, relief was on the way, "So, for the best way to pass your cel check ride and get good grades on your celestial procedures, just follow these 36 basic steps..."

Until the advent of the new generation of programmable calculators and computers, I methodically accomplished these 36 basic steps in computing my celestial observations to pass my check rides. After reviewing these forgotten concepts and purchasing one of these new calculators, I discovered that I could precomp my celestial observation in less than one minute, resulting in an easier, more accurate, and timely approach to celestial navigation.

This article will refresh your memory in these forgotten concepts. With this information, I will explain a few practical applications using a great circle program to obtain a true bearing (Zn) and a computed altitude (Hc) in a moment's time. This should be quite useful since many aircraft are now equipped with such a program in their OMEGA or INS navigation computers. If your aircraft does not have this capability, there are several programmable computers on the market that have a great circle program within either the calculator or a removable module. This system is not intended to replace manual precomp procedures; it simply demonstrates a different approach in celestial fixing. Just as Latitude by Polaris is a quick and easy method for obtaining a reliable line of position, so can a computer aid your celestial procedures.

The 36 steps previously mentioned involve using the Air Almanac and the H.O. 249 celestial tables to define the astronomical triangle in terms of the local hour angle (LHA) of the celestial body. The finished product is found in the appropriate H.O. 249 table in terms of a given LHA, latitude, and declination (Dec), from which the Hc and Zn of the body are resolved. The celestial tables use the specified values of latitude, LHA, declination, and time of observation to define the relative positions of the observer and the subpoint of the body.

Using a great circle program, you can determine the co-altitude distance between the observer and the subpoint, and then convert this distance to degrees. In reviewing the vertical depiction of the astronomical triangle (Figure 1), note the basic concepts of altitude and co-altitude in terms of arc degrees and arc minutes; remembering that in celestial geometry one arc minute equals one nautical mile.

Again using celestial geometry, the altitude angle (Hc) can be determined by subtracting it from 90 degrees. Since the Celestial North Pole and True North Pole are defined as being the

same, the true bearing obtained from the observer to the subpoint is also, by definition, the Zn of the body.

To demonstrate using a great circle program in determining the Hc and Zn of a given body, I will explain a step-by-step procedure in obtaining these values.

You will need to define two waypoint positions in terms of earth coordinates. The first point, that of the observer, can be the latitude and longitude of your DR for the given shot time.

The second position that needs to be inserted into the computer is the subpoint of the body. Reviewing AFM 51-40, *Air Navigation,* the subpoint of a body can be determined by using the Air Almanac for the given shot time. Example: using a sun observation for a DR position of 53°12′N, 028°14′W at 1150Z, a GHA of 001°34.3′ and a Dec of S 13°45.2′ are found in the Air Almanac. Remember, the subpoint position can be determined by converting Dec to latitude and GHA to longitude by the following equations:

Latitude = Declination
West longitude = GHA (if GHA is less than 180 degrees)
East longitude = 360° −GHA (if GHA is greater than 180 degrees)

In this example, the subpoint is located at 13°45.2′S and 001°34.3′W at a shot time of 1150Z.

Now that DR and subpoint coordinates have been defined, use the computer to calculate the great circle distance (co-altitude) and the Zn from the DR (as the assumed position) to the subpoint of the celestial body. The distance in this example should be 4245 nautical miles or arc minutes. The true bearing (again, the Zn in all cases) will be 152.5°. Remembering the celestial angular relationship to earth, distances of one degree are equivalent to 60 nm, one now needs to convert the co-altitude distance into degrees. This conversion is done by dividing this distance by 60. The answer is 70.75°.

Reviewing the illustration, the next step is to convert the co-alt angle to the altitude angle. This is done by subtracting the co-alt from 90°:

Hc = 90° − co-alt
Hc = 90° − 70.75° = 19.25°

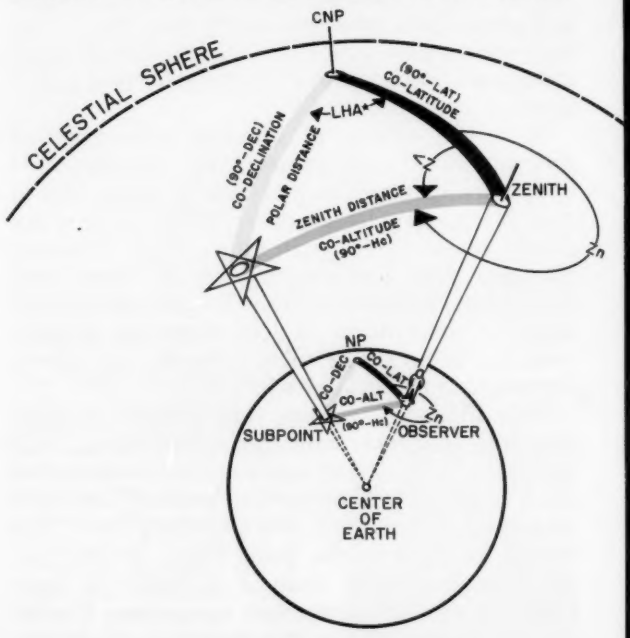
The Hc is in decimal format. Conversion to arc minutes can be done by a special subroutine in some computers or by constructing a conversion table.

Thus: Hc = 19°15′

Now shoot and resolve your celestial observation. Using the DR as the assumed position provides a more accurately plotted LOP. Instead of moving the assumed position to obtain an LHA and latitude for use in the H.O. tables, you can use an accurate DR as your plotting position, resulting in very small intercept distances (toward/away). With a smaller intercept distance, the likelihood of plotting errors as well as shooting the wrong celestial body is greatly reduced.

These five steps can be inserted into various hand-held programmable computers. One can input the assumed position as the first position and the subpoint as the second position. The calculator will then compute the great circle distance between these two points, as well as the true bearing. Next, convert this distance to whatever usable product is needed to resolve the fix. I have a TI-58 calculator with an aviation module which I have successfully used many times on the ground as well as airborne. The big time saver is obtaining a very accurate heading shot precomp in less than one minute.

USAF C-130 aircraft have been equipped with an OMEGA navigation system, the AN/ARN-131. The OMEGA computer can also be used for precomps, but system operation necessitates a different method of inserting the coordinates. One method is to input the subpoint coordinates as a computer waypoint. By using the OMEGA



ASTRONOMICAL TRIANGLE

crosstrack/distance (XRT/DIST) function and pressing the waypoint number corresponding to the subpoint coordinates, a spot reading will appear indicating the great circle distance and true bearing from the OMEGA's present position to the waypoint selected. Although one can freeze the present position display, the distance and true bearing readings must be a spot reading.

I normally use two techniques with the OMEGA. The first technique is to record the present position, distance, and true bearing before and after the shot, then average these figures for the mid-time of the observation. The other technique is to jump down from the sextant at the mid-point of the shot, freeze my present position, record the distance and true bearing, then jump back up and finish shooting. For this last technique, have another crew member help you record the data at the middle of the shot. KC-135 navigators have the luxury of boom operators to shoot for them.

There are various inertial navigation systems in the present inventory ranging from C-141s to a newly installed INS in the KC-135. These systems can determine the great circle distance and true bearing between two waypoints. In some models, you can obtain your results by either waypoint to waypoint or by present position to a particular waypoint. Check the appropriate tech orders to insure a true bearing and great circle distance are obtained rather than a rhumb line course and distance.

As with any system, check the program by using known points, particularly two points along the same longitude. This will give you either a 360° or 180° true bearing and a distance equal to the differences in latitude. Some INS computers have a small error of 2 to 5 nm within their great circle program distances. A Delco representative commented that this error is the actual distance since their software incorporates an elliptical rather than a spherical shaped earth. He further noted that the true bearings may have a few degrees of error from waypoint to waypoint if the present position of the aircraft is significantly away from the two waypoints. However, the true bearing will be accurate from present position to the particular waypoint. The OMEGA technique of using present position to a given waypoint is therefore recommended. The OMEGA and INS may also round up or down to the nearest degree, again depending on the model. Test your system and determine how much error is acceptable to you and your command.

To review the computer precomp procedures:

1. Define the coordinates: *
   DR = Assumed Position
   Subpoint:
   Latitude = Declination
   West Longitude = GHA (if GHA is less than 180°)
   East Longitude = 360° − GHA (if GHA is greater than 180°)
2. Determine co-alt (great circle distance) and Zn (true bearing from assumed position to subpoint).
3. Convert co-alt to degrees: $\frac{\text{Co-Alt}}{60}$.
4. Determine Hc by: Hc = 90° − co-alt.
5. Convert Hc into arc degrees and arc minutes.

*For stars, refer to the Air Almanac for Dec and convert the GHA of Aries to a GHA for the star:

GHA (Aries) + SHA (star) = GHA (star)

I have mentioned a few steps for using computers to calculate an Hc and Zn of a celestial body. Keep in mind the celestial concepts as well as the different approaches in obtaining these values. These procedures save time, make the job a little easier, and, in most cases, provide a more accurate precomp. Check with Stan/Eval within your command to see if they will allow a different approach to precomp procedures. In comparison, 5 steps are better than 36!

Editor's Note: Many INS units offer the information needed to resolve a celestial precomp; however, you may have to vary the author's suggested procedures depending on the program logic of your particular INS model. For example: most INS units compute the distance only from present position to a selected waypoint, rather than from one waypoint to another. Furthermore, a Zn difference of several degrees may occur if the true bearing obtained is derived from the mid-longitude of the leg rather than from your present position.

Capt Turner received his ROTC commission upon graduation in 1973 from West Virginia University as an aeronautical engineer. Initially assigned to Eglin AFB, he completed UNT in 1975 and was then assigned to the C-130 at Dyess AFB. Capt Turner presently is a Flight Test Nav for all DoD C-130s at the DCASPRO, Hayes Aircraft Corp, Birmingham, AL.

NAVIGRAMS

We are proud to present the navigator leaders recently selected for promotion to Brigadier General and Colonel, respectively. Congratulations and best wishes for continued success from THE NAVIGATOR.

BRIGADIER GENERAL SELECTEES

Colonel Donald W. Goodman
Executive Officer to the Chief of Staff, SHAPE
Supreme Headquarters Allied Powers Europe, Belgium

Colonel Allen K. Rachel
Assistant Deputy Chief of Staff for Operations Plans
Headquarters Strategic Air Command
Offutt Air Force Base, Nebraska

Colonel Elbert E. Harbour
Director, C-X Transport System Program Office
Aeronautical Systems Division
Wright-Patterson Air Force Base, Ohio

Colonel Bernard P. Randolph
Deputy for Space Defense Systems
Worldway Postal Center
Los Angeles, California

Colonel Maurice C. Padden
Commander, 443d Military Airlift Wing
Altus Air Force Base, Oklahoma

Colonel Larry N. Tibbetts
Assistant for Colonel Assignments
Headquarters Air Force Manpower and Personnel Center
Randolph Air Force Base, Texas

COLONEL SELECTEES

Armstrong, Frederic C.
Ballentine, John W.
Battreall, Raymond J.
Baulch, William N.
Bean, Wesley W., Jr.
Benjamin, Juan H.
Benten, William A.
Berg, Donald J.
Bester, Joseph D.
Biron, Edward J.
Bollenbach, Merle E.
Botticelli, Allan P.
Brady, Conal J., Jr.
Briscoe, Thomas R.
Brown, Bruce A.
Brown, Donald L .
Broyles, Gene T.
Carr, Bruce L.
Chick, Jason I.
Cilvik, Reginald M.
Clark, Thomas S. , Jr.
Craveiro, Richard C.
Dabbs, Travis D.
Dale, Curtis D.
Davis, Jon L.
Desjardins, Philip D.
*Donahoe, James B.
Dunham, Robert L.
Dykes, Conley H.
Fair, Gordon H.
Fedor, William P .
Fitzgibbon, James J.
Grimes, William D. W.
Hackett, Robert D. , Jr.
Hall, Franklin D .
Hannan, George P.
Heilman, James H.
Henry, George A., Jr.
Herget, James D.
Hildebrand, Leland L.
Hill, Lincoln
Hines, Walter E. III
Hinnebusch, Michael L.
Hollrah, Gene R.
Holman, David K.
Honaker, Harry R.
Huffman, Leon W.
Johns, Delman A.
Johnson, Harold E.
Johnson, Howard R.
Johnson, Richard A.
Jones, Herman P.
Kane, Edmund T.
Knutson, Donald E.
Laferriere, Roy R.
Lehnertz, David K.
Lesher, Neal E.
Lewellyn, Edwin D.
McGrath, Denis P.
McMillan, Frank D.
McNabb, David R.
McNeill, Ken B.
Miller, Warren L.
Molina, Ivan A.
Moore, Ernest F.
Moore, Stephen F.
Mulligan, Michael E.
Munechika, Ken K.
Murphy, Francis R.
Neal, Harold R.
Nutt, Donald G.
Nylander, Jon D.
Oliveri, Robert A.
O'Neil, Robert E.
*Peirolo, Ernest C.
Pelini, Louis V.
Pontius, Earl A.
Quist, Bernard W.
Randall, William V.
Ratner, George H.
Redican, Edward C.
*Reed, David C.
Reeves, John M.
Remson, Jack G.
Samuel, Wolfgang W. E.
Schmoll, Ross V.
Smith, Allan T.
Snyder, James M.
Spacy, William L.
Spezia, Jimmie V.
Stambaugh, William S.
Staud, John J., Jr.
St Clair, Gilbert K.
Stoddard, David D.
Streitmatter, Larry A.
Sullivan, Edwin N.
Summers, Charles E.
*Tessmer, Arnold L.
Thomas, Edward
Walker, Belva D.
Walker, Roy A.
Wallace, Richard P.
Waterman, Quintin L.
Watson, Richard E.
*Willette, James F.
Wood, Harry F., Jr.

*SECONDARY ZONE

NAVIGATOR INTEREST RUNS HIGH AT THE UNIVERSITY OF FLORIDA

Air Force ROTC cadets at the University of Florida are learning as much as possible about the role of the Air Force navigator before making their career selections. A Navigator Club at AFROTC Detachment 150 has been established to acquaint cadets with Undergraduate Navigator Training and what to expect when assigned to an operational unit.

The Club continues to search for a wider variety of information on the navigator career field via Air Force films, small group seminars, guest speakers, current information files, and correspondence with active duty personnel. Navigators interested in helping Air Force ROTC cadets learn about this challenging and changing profession are invited to share their experiences. Contact Captain Bert Varady, club sponsor: (904) 392-1355.

STARGAZING FOR FUN

Captain Stephen P. PAPPAS
509 AREFS
Pease AFB, NH

What is perhaps missing in today's highly technical and practical view of the celestial sphere? Fun! Most articles dealing with celestial navigation, though very helpful to dedicated navigators, are sometimes comparable to reading AFTO "Dash Ones." They're not fun. It's all well and good to understand every aspect of your particular aerospace vehicle, but just think what would be missing if the act of flying were not enjoyable—if flying was not fun.

Awed and confused. That's how I felt a few years ago as I gazed for the first time under the hood of my car. What chaos! Auto mechanics unquestionably held the rank of four-star magicians—until a knowledgeable friend spent 30 minutes with me under the hood. Out of the multi-dimensional chaos emerged an understandable, unified order of things.

Can you relate to my experience? If you can, just remember there is only one year and model of sky to understand, although the stars do rise about four minutes earlier than they did the night before. Four minutes here, four minutes there...it adds up. Each night the sky advances by approximately four minutes due to the Earth's revolving around the Sun. Hmm. Looks like a good place to begin.

POLAN. No, I didn't forget the "D." POLAN is an acronym for five easily identifiable groups of stars, at least one of which is overhead on any night. Pegasus, Orion, Leo, Arcturus, and the Navigator's Triangle each take turns dazzling us with their marvelous twinkles. Orion the Hunter is the winter constellation and the most easily identifiable group of stars in the sky. On a clear winter evening around midnight, look directly overhead and you can't miss him. The three stars that form his belt are his unmistakable signature.

As the months pass by and the Earth continues its orbit around the sun, Orion will begin to set in the western sky and Leo the Lion will take the overhead position in early spring, again around midnight. Late spring brings the Arc of Arcturus into view. Then, in the summer, comes the Navigator's Triangle. And in the midnight autumn sky, Pegasus spreads its wings overhead. Orion will then be rising in the eastern horizon to begin the endless procession once more. Hard to remember? Just remember that Orion is the winter constellation and the rest comes naturally... POLAN.

These star groups are all easily identifiable, but where do you begin? Where's east at night? How about the North Star, Polaris? Can you find it? Hmm. Something about the Big Dipper...Right? The two pointer stars of the Big Dipper (Ursa Major, or the Great Bear) point directly to Polaris, the North Star (part of Ursa Minor, you guessed it, Little Bear). Before we continue, some very important words about Polaris. It has often been called "God's gift to navigators." And for some very good reasons.

For stargazing purposes, Polaris is the only star in the sky that does not "move," hence it is visible from any point in the Northern Hemisphere at any given time. All of the stars in the sky "rotate" around Polaris in a counterclockwise direction. If you can imagine the sky as an LP record, Polaris would be the hole and all the other stars would take their places somewhere on the vinyl. If you were to aim your trusty 35mm camera at Polaris and leave the shutter open for, say, an hour, all of the other stars in the Northern Sky would move counterclockwise forming concentric rings around Polaris, the fuzzy dot in the center of your picture. Of course, none of the stars actually move or rotate, but appear to because the Earth spins on its axis. If you were to extend this axis about 470 light years, it would pass through Polaris. It doesn't move. Polaris

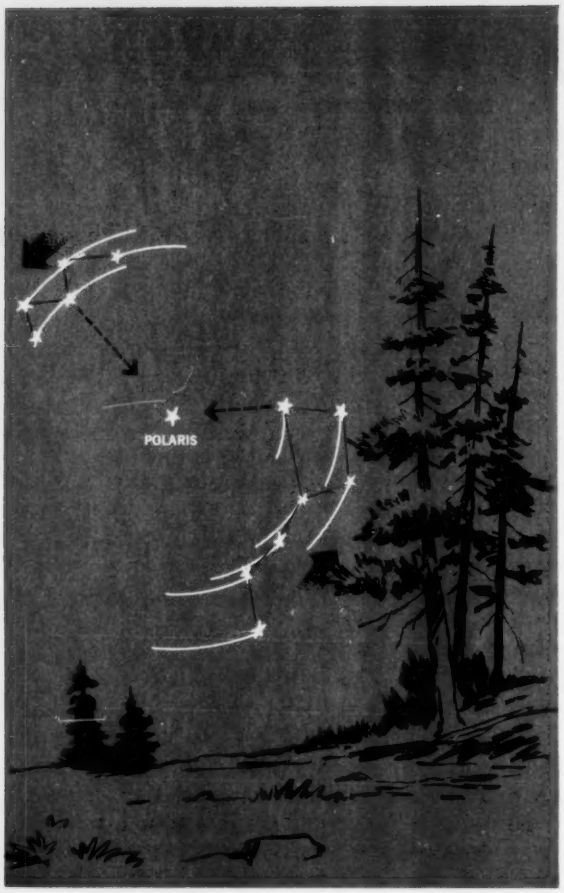


Figure 1
1 HOUR TIME LAPSE PICTURE OF POLARIS. ALL OTHER STARS HAVE "MOVED" 15 DEGREES COUNTERCLOCKWISE AROUND POLARIS.

represents True North far better than your variation-affected magnetic compass. Walk toward Polaris and you'll eventually arrive at the North Pole.

So now you can find Polaris, True North, by following the two pointer stars of the Big Dipper, right? Sometimes. Each day as the Earth rotates, the Big Dipper, or a part of it, sets farther below the horizon. One of Polaris' few drawbacks is that it is relatively faint and needs to be pointed out somehow. Don't worry. When the Big Dipper is setting in the west, another prominent constellation is rising in the east.

The five stars in this constellation, the Chair of Cassiopeia, look like a W or M, depending on whether rising or setting, and are easy to find and identify. When the Big Dipper has long set below the horizon and is directly below Polaris (i.e., you can't see the dipper), Cassiopeia is now an M, and is directly above Polaris with the middle of the M pointing down to Polaris. Queen Cassiopeia's chair and the Big Dipper constantly maintain this 180 degree relationship with Polaris exactly in the middle, so you can always see one, and sometimes both, of these constellations pointing to the North Star. After you've learned to find Polaris, you will not need a compass on a clear night and should never get lost.

We know that the five star groups of POLAN are observable depending upon the season. For instance, you cannot see Orion in the summertime. He happens to be overhead, but only during the daylight hours. However, quite a few star groups that "rotate" around Polaris can be seen every night due to their proximity to Polaris, which (1) never moves, and (2) is always visible in the Northern Hemisphere. Because these particular stars are so far north, they set below the horizon only for short periods of time. Cassiopeia, the Big Dipper, Little Dipper and others are in this North Sky Circle. I'd advise you to find these groups first, then look overhead to the east and west for members of POLAN, of course, depending on the season. Tonight around midnight, Leo the Lion will be overhead; Orion will be setting in the west; and the Arc of Arcturus will be rising in the east.

One warning before you seriously gaze at the stars: beware of planets. "Planet" means wanderer—and wander they do. Since the planets revolve around the sun on much the same plane as the Earth (within three degrees), they appear to move overhead in a narrow band of the sky. That band is known as the zodiac. Although only four of the planets are easily visible, the zodiac unfortunately runs through the star groups of POLAN. Since the planets look like very bright stars and have very irregular motions, they can really play havoc with the unaware gazer's best intentions.

A little history on the origin of constellations and star names may be helpful. Thousands of years ago the stars were individually named by the ancient Arabians, hence the odd-sounding names: Schedar, Alioth, Dubhe, etc. At first I was surprised that the stars weren't named by a seafaring people, such as the Phoenicians or Greeks, who needed the stars for obvious navigational reasons. Then a couple of years ago I was flying over Saudi Arabia between Jeddah and Dhahran. It was a typical airways mission, but I was busy backing up the VORs with radar—and having a very difficult time. Eventually we flew over a large area on my ONC annotated, in effect, that this region was still uncharted. I

decided to look out the window, (which I am apt to do occasionally) and to my amazement, there simply is not a whole lot to navigate with from the ground! Nothing but lots of sand and hot, hot air. Lesson learned: you better not get lost if you ever decide to cross a desert area, especially on foot. I know that must sound rather obvious, but at the time there was a light bulb clicking over my head, a sudden realization, if you will. Even so, to identify the stars individually must have been an immense task. Later on, the ancient Greeks "connected-the-dots" and, with a magical touch of their mythology, created most of the constellations as we know them.

POLAN begins with "P," which stands for Pegasus—the winged horse. There is no way I can see a horse flying through the sky in the group of stars the Greeks named Pegasus! If it's any comfort to you, neither did a lot of ancient Arabians. I see a very mundane, 20th century baseball diamond. And if you take the time to look, you will too. The diamond is remarkable because it is devoid of any other stars. It is completely black in the "infield" while the four "bases" are among the brightest stars in the sky.

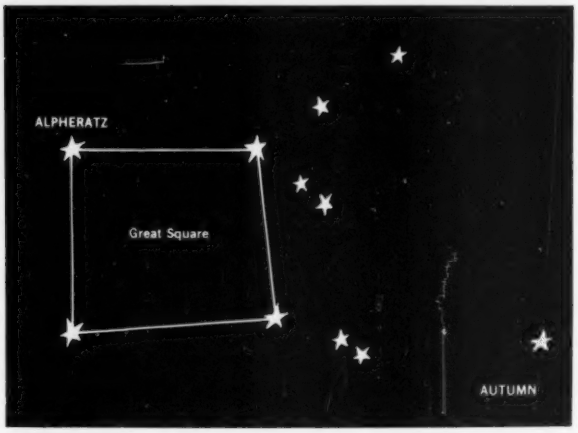


Figure 2

PEGASUS

"O" is for Orion the Hunter, my favorite constellation for a number of reasons. First, he is the easiest to identify. Furthermore, Orion clearly points out six other star groups. But Orion's most significant contribution to the stargazer is his position in the sky: Orion is the central figure of six other important star groups that are easily identified once you have located the Hunter. Look at the enlarged diagram of Orion. If you don't cut out this picture and spend five minutes outside early tonight looking toward the western horizon where Orion is beginning to set, you'll be passing up a most rewarding stargazing experience.

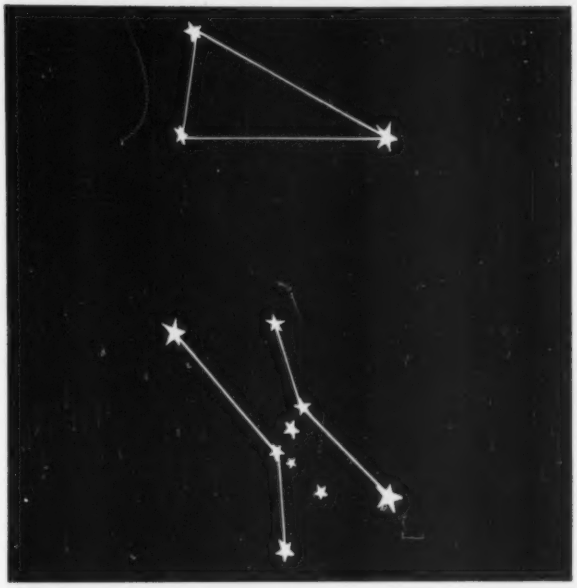


Figure 3

ORION with Taurus

Leo the Lion, though not as abstract as Pegasus, is fainter and a bit more difficult to see. Leo can indeed look like a lion, but other less imaginative gazers will probably see a large coat hanger, capped with a sickle. Look to the west for Orion tonight, then directly overhead for the sickle and, voila! A lion! Or, more probably, a coat hanger.

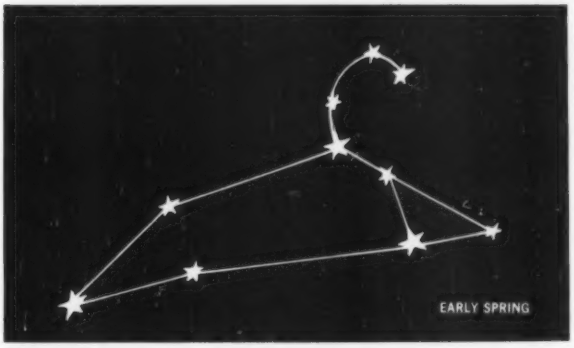


Figure 4

LEO THE LION

The Arc of Arcturus (the "A" in POLAN) is not a constellation, but a grouping of stars visible

overhead in the late spring. After Orion, the Big Dipper is the easiest constellation to find. If you extend the Dipper's handle an equal length away from the lip stars, along the same bend, you'll find the bright Arcturus with no problem. Continue along this arc for the same distance to find the bright star, Spica. Half again as far, and you come to a star group with Gienah—the brightest. Oddly enough, to complete the Arc of Arcturus, you leave the arc and go to Alphecca, a bright star offset between Arcturus and the handle of the Big Dipper. This may confuse things a bit, but somehow I still remember how it was taught in nav school. "Arcturus, Spica, Gienah, Alphecca." Good luck.

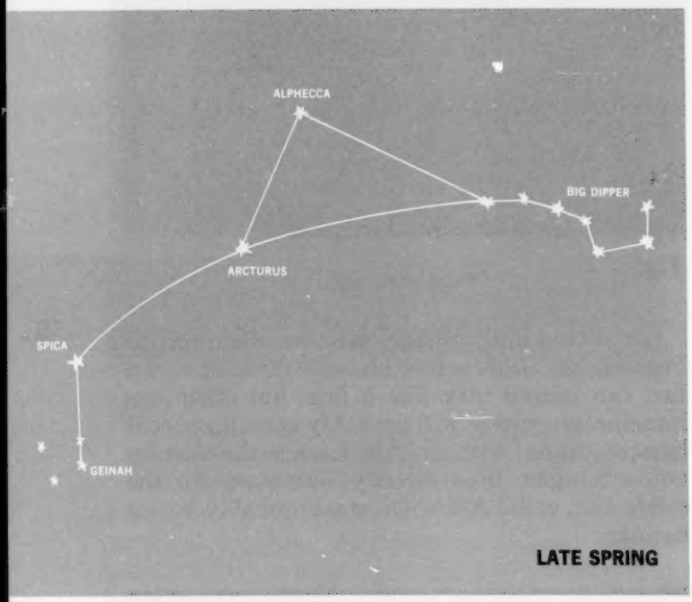


Figure 5

ARC OF ARCTURUS

"N" is for The Navigator's Triangle which is not a constellation either, but is very easily seen. This summer, or late tonight rising in the east, look overhead for a 30-60-90 degree triangle of three extremely bright stars. And remember one thing—it's huge! The Big Dipper can fit inside it. After a while, your eyes will become accustomed to the dark sky and more stars will become visible. Then look for Cygnus, the long-necked swan, sometimes called The Northern Cross. Cygnus' tail is the bright star, Deneb, and the Swan always maintains flight in the middle of the triangle. As I mentioned earlier, the Navigator's Triangle will be rising a bit later tonight and can be easily seen by looking to the eastern horizon after midnight.

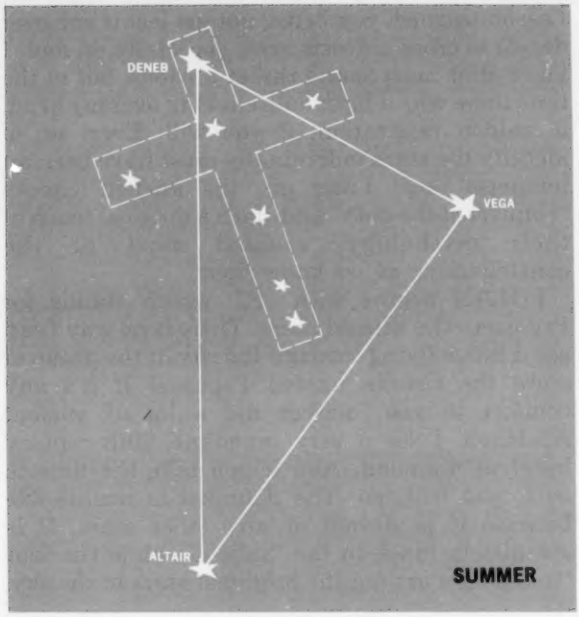


Figure 6

NAVIGATOR'S TRIANGLE
with Northern Cross

So there you have it; probably more than you want. But what are we talking about? Remember, daylight lasts approximately 12 hours, but that doesn't mean you must remain in the dark. The sun is a very insignificant body when measured in size and intensity against billions of others. We're talking about the vast universe. If you choose to make "sense" of the night sky, to remove much of the chaos and observe the infinite universe with a more comfortable perspective (at least more knowledgeable), then a lot of tools are now in your hands. You need only a small investment of time, a clear night and a tad of patience. And, it's fun to boot!

Capt Pappas graduated from Webster College in 1977 with a master's degree in Human Relations and Public Administration. After completing UNT in 1974, he served as a C-130 AWADs instructor, 41 TAS, Pope AFB. Capt Pappas presently is a KC-135 navigator with the 509 AREFS, Pease AFB.

AOC Duty for Navigators

Captain Benjamin C. PITTMAN
HQ USAFA/CWDS-34
USAF Academy, CO

Commander—For many "blue suiters" that word means more than any other because it represents not only the highest authority, but also a goal that many of us seek. Unfortunately for most rated officers, command positions come during the latter years of a career—if at all. There could be, however, a commander's job for you as a senior captain or major, if you are qualified. The slots are few, the competition is keen, and the challenge is great—but the rewards are outstanding.

Presently at the United States Air Force Academy, 40 officers serve as cadet squadron commanders. Traditionally, the position has been titled "Air Officer Commanding" or AOC, but the official duty title is "Commander, Cadet Squadron"—the Air Force Specialty Code (AFSC) is A0900. Filling the slots this year are 6 navigators, 19 pilots, 11 nonrated, and 4 exchange officers; the desire is to expose the cadets to the officer mixture they will encounter on active duty. In order to have a clearer perspective as to what the job entails, some background information on the Academy is necessary—for the "Grads" reading this article, you can merely reminisce.

The Institution

Located by the Rampart Range of the Rocky Mountains, with Pikes Peak towering in the background, the Academy can best be described as "majestic." Clear skies, snow-covered mountains, wild deer roaming the reservation . . . the site is indeed a nature lover's paradise. The physical structure of the Academy is equally breathtaking. The buildings are designed in contemporary architectural style, featuring glass, aluminum, steel, and white marble. The Academy Chapel is probably the number one attraction in Colorado; thousands of tourists visit Colorado Springs every year just to see this unique structure. The Academy offers much more than mere beauty. For openers, the mission requires every support organization normally found at an operational base, as well as many unique ones. In addition, the recreational facilities are the best in the Air Force with 2 olympic-size swimming pools, an indoor track, an ice hockey rink, 32 tennis courts, about 20 each racquetball and squash courts, and much more. If you ever wanted to devote some time to physical fitness, this is the place!

An Air Force Academy graduate receives a Bachelor of Science degree and will have accumulated approximately 180 semester hours. The curriculum consists of many "core" courses not found in a regular university syllabus. These subjects include computer science, mechanical engineering, physics, aeronautics, behavioral science, political science, and astronautics—every cadet must take them all. The objective: prepare the Academy graduate to meet the technological changes in our aerospace environment. To further enhance instruction and help the cadet identify with his or her profession, almost every academic, military, and athletic course is taught by a commissioned officer.

The Cadet Wing

The Cadet Wing functions under a dual chain of command—the officer chain and the cadet chain. Ultimate responsibility for the Wing rests with the officer chain, starting with the Superintendent (Lt Gen), moving through the Commandant of Cadets (Brig Gen), the Deputy Commandant for the Cadet Wing (Col), the Group Air Officers Commanding (Lt Col), to the Squadron AOCs. The Squadron AOC is the unit commander—he or she must bridge the gap between the officer chain and the Cadet Wing and orchestrate the academic, physical, and military aspects of cadet life to produce the best possible Air Force officers.

The Cadet Wing is commanded by a Cadet Colonel, Wing Commander, and his/her staff. Under the Wing Commander are 4 Group Commanders and 40 Squadron Commanders. The remaining cadet officer positions are filled by Seniors or First Classmen, with approximately 900 First Class cadets in the class of 1980. Most NCO positions are assigned to Juniors, while the Third Class cadets primarily train the "Doolies" or Freshmen. The wiring diagram (Figure 1) describes the chain of command in a typical cadet squadron. The duties provide the cadet with responsibility and exposure to functions in the operational Air Force. In each position, the cadet tests and develops leadership potential. Mistakes are expected; they are critiqued and used for the overall positive development of the officer candidate.

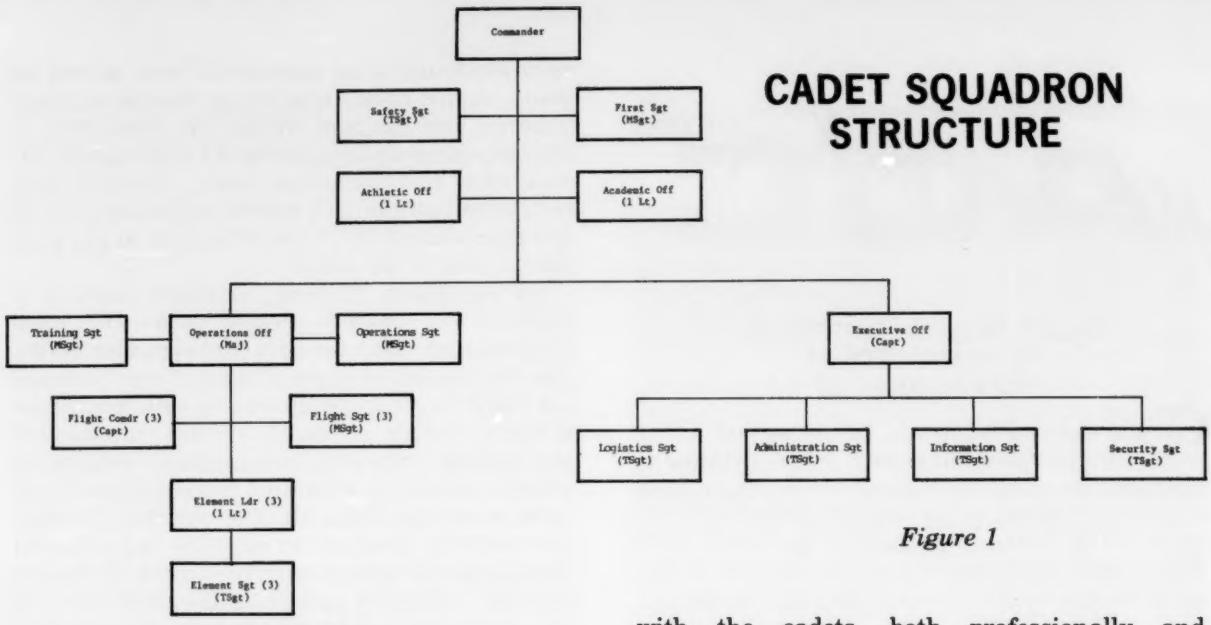


Figure 1

The AOC Role

Like any commander, the AOC is responsible for the health and welfare of his/her people; but that's just where the responsibility begins. The AOC is here to support a mission, and that mission is to train and motivate cadets so that they graduate with the knowledge and character essential to leadership. The Academy provides a leadership laboratory for the cadets so that they may experience responsibility and command—the AOC provides the guidance necessary to keep them on track. The AOC role can be equated to that of an instructor navigator or instructor pilot. If the instructor is too complacent, the student will crash; if too restrictive, the student will be poorly trained. Motivate and train while maintaining the highest standards—there is no secret formula for achieving that goal; each AOC must develop the leadership style best suited for the unit.

Just how involved must the AOC be with regard to squadron activities? Intimately! There is a cadet chain of command, but, remember, their job is to learn, and learning means making mistakes. The AOC, alone, must provide the command and control necessary to achieve unit and mission success. The key word is involvement. To insure quality training, the AOC supervises formations (intramurals, drill, parades, meetings, etc.), inspects cadets and cadet rooms, eats with the squadron frequently, and reviews cadet correspondence. Motivation comes from both the AOC as a role model and from frequent counseling to provide feedback on performance and give insight into Air Force careers. In a nutshell, the AOC must be intimately familiar with the cadets, both professionally and personally.

Standards, Discipline, Rating

How familiar those three words are! At the Academy, however, they take on a special meaning. Through Academy and Cadet Wing regulations, the cadets are exposed to a demanding set of standards. The standards are purposely high so that cadets can establish firm foundations in self-discipline and leadership early in their careers. The discipline system is designed for that small percentage of cadets who do not adequately develop their self-discipline and professional attitude toward training. A good cadet will not suffer from a few minor offenses but, through the discipline system, repeated substandard performance can be easily identified.

Oh, yes, the cadets are also rated—on a form similar to our OER. The cadet's overall performance is evaluated based on inputs from the cadet chain of command, the academic instructors, the coaches of intercollegiate athletics, and the AOC. With this rating, the AOC can identify marginal cadets and then provide the counseling, monitoring, and assistance necessary to correct deficiencies.

Fringe Benefits

The AOC must work as hard as any commander in the Air Force because the mission is so very important—but the rewards are there. Not the A-prefix, not the title, and not a general's indorsement on an OER (though these are some of the tangible benefits), but the personal satisfaction in knowing that you have helped

mold the leaders of tomorrow's Air Force. Certainly, there can be no higher calling. When that sharp cadet comes in and says he has decided to go to nav school, or on graduation day when you see 900 new second lieutenants throw their hats in the air—those are the fringe benefits.

For all you OTS and ROTC grads, I hope you have a better understanding of the job of the Air Officer Commanding. For you Academy grads, I am sure that I have brought back memories. The AOC is a special type commander, and I know that there are many navigators with the abilities necessary to handle the job. If you're interested, visit your CBPO and check on application procedures. Or better yet, try and get out this way and "check it out"—I think you'll like what you see. If you don't know any of the following navigator AOCs, come by the 34th Cadet Squadron and I'll be glad to show you around.

AOC	*Unit*	*Phone*
Lt Col Jerry E. Singleton	4th Group	2183
Lt Col Kenneth R. Lawrence	DEP 4th Group	2183
Maj Dennis P. McGuirk	4th Sq	4541
Maj Larry C. Bagley	9th Sq	4552
Maj George E. Long	14th Sq	4767
Maj Joseph J. Maguire	28th Sq	4408
Capt Ben C. Pittman	34th Sq	4444

Capt Pittman (major selectee) entered the Air Force in 1968 via ROTC at Clemson University. After UNT and NBT, he was assigned to the B-52H at Wurtsmith AFB. He completed two Arc Light tours and then filled supplement jobs at Hurlburt Field where he also flew the AC-130H. Capt Pittman is the AOC for Cadet Squadron 34, USAF Academy.

THE PROGRAMMABLE CALCULATOR AS A NAVIGATIONAL TOOL

Lieutenant Colonel Frank T. HALOOSTOCK
HQ ASD/AER-EA
Wright-Patterson AFB, OH

I have written this article to help the navigation community obtain a better understanding of the modern programmable calculator. My interest in the airborne uses of programmable calculators was aroused after reading several articles in the *THE NAVIGATOR, FIGHTER WEAPONS REVIEW,* and *JOURNAL FOR THE INSTITUTE OF NAVIGATION.* I have been using programmable scientific calculators for the past five years in my position as an electronics engineer at the Aeronautical Systems Division, Wright-Patterson AFB, Ohio. This, along with my previous experience as a C-130 and AC-130 navigator, has given me some thoughts on the advantages of programmable calculators in navigation. Many of the lessons learned in using these calculators for solving engineering problems apply to navigation. At the same time, unique conditions on the ground and in-flight present new and challenging considerations.

First, what is a programmable calculator? It is a device which can memorize a sequence of keystrokes and can be programmed to make logical decisions. A new operator usually performs computations the same as on regular calculators, except that the keystrokes are entered into the memory as a program. This ability to memorize long sequences of keystrokes is one of the main arguments for using programmable calculators, since the chance of erroneous key entry is greatly reduced.

For example, the equation for the Great Circle distance between two points is: Dist(nm) = 60 x $\cos^{-1}[\text{SinLat}_1\text{SinLat}_2+\text{CosLat}_1\text{CosLat}_2\text{Cos}(\text{Long}_2-\text{Long}_1)]$.
Where the departure coordinates = Lat_1, Long_1 and destination coordinates = Lat_2, Long_2.

A typical calculator would require over 50 keystrokes to solve this problem. The same computation performed on a modern programmable calculator might use the following keystroke sequence:

XEQ ALFA G C ALFA Lat 1? 4 0 . 0 0 R/S Long 1? 8 3 . 0 0 R/S Lat 2? 4 9 . 0 0 R/S

Long 2? 2 . 1 5 CHS R/S GC DIST = 3489 nm

This example uses Columbus, Ohio, 40-00N, 083-00W and Paris, France, 49-00N, 002-15E, as departure and destination points.

First, the great circle program (GC) is called: XEQ ALFA G C ALFA. The calculator then asks for latitude; LAT 1? Latitude 1 is entered as 4 0 . 0 0 R/S. The sequence is repeated for Longitude 1, Latitude 2 and Longitude 2. The calculator then completes the computation and outputs the answer: GC DIST = 3489 nm. Because the longitude of Paris is east, it is entered as a negative number: CHS. Notice that the operator had to provide only the calling of the program and the coordinates of the departure and destination points. The keystroke count for this example was 29.

Compare this keystroke sequence to that of a manual calculator:

4 0 . 0 0 HR SIN 4 9 . 0 0 HR SIN X 4 0 . 0 0 HR COS 4 9 . 0 0 HR COS X 2 . 1 5 CHS HR

8 3 . 0 0 HR - COS X + COS^{-1} 6 0 X = 3489.

For this example, the keystroke count is 50. For less efficient calculators using an algebraic operating system, i.e., parentheses and equal signs, the keystroke count would be 58.

It might be useful at this point to stop and review the evolution of current programmables.

Table 1

Evolution of Programmable Calculators

Spring 1972	-	First Pocket Scientific Calculator—$400, Trig and scientific functions.
Fall 1974	-	First Pocket Programmable Calculator—$750, 100 nonmerged steps, magnetic cards.
Spring 1977	-	Expanded Capability Programmable—$395, up to 960 semimerged steps or 100 data registers, magnetic cards, specialized preprogrammed modules, and separate printer.
Summer 1979	-	First alphanumeric pocket programmable—$295, liquid crystal display, 9-12 month battery life, memory expandable from 400 to 2,000 program lines, specialized modules, magnetic cards, printer.

This table clearly shows the trend toward more capability at a lower cost (a characteristic of microelectronics). The prices shown are especially significant considering the cost of living increase between 1972 and 1979, which would make the price of the first calculator almost $800! If this trend continues, a true personal computer (which will fit in a brief case) will be available by 1982.

Table 2

Features of Current Programmable Calculators

1. Alphanumeric liquid crystal displays.
2. Ultra-low power consumption, with 9-12 month battery life.
3. Constant memory, which means that neither the program nor stored data is lost if the calculator is turned off. In fact, some calculators turn themselves off to conserve power if no key has been depressed for 10-15 minutes!
4. Merged instructions, combining several key strokes into a single line of program instructions, allowing longer programs.
5. Permanent program storage using magnetic cards or ordinary cassettes, allowing rapid program changes with minimal errors.
6. Preprogrammed memory modules, permitting users to tailor the calculator to their needs. This could lead to specialized modules for the C-130 troop carrier, B-52 radar nav, F-4 WSO roles, etc.
7. Segmented memory, permitting any combination of program and data storage.

What can the programmable calculator do for navigation? The following discussion will use a preflight calculator program to point out the power of the programmable calculator.

The modern programmable, because of its large memory capacity, can store several programs and allow them to be strung together into a larger program corresponding to the navigator's sequential tasks during flight planning. Because of the complex interrelationship of these programs, a "road map" or flow chart should be drawn to assist in writing the individual program. This flow chart is indispensible in generating efficient programs since it diagrams the logic and actions taking place inside the calculator program. Remember, a program is simply the sequential listing of a series of keystrokes normally performed by the operator.

A simple flow chart is:

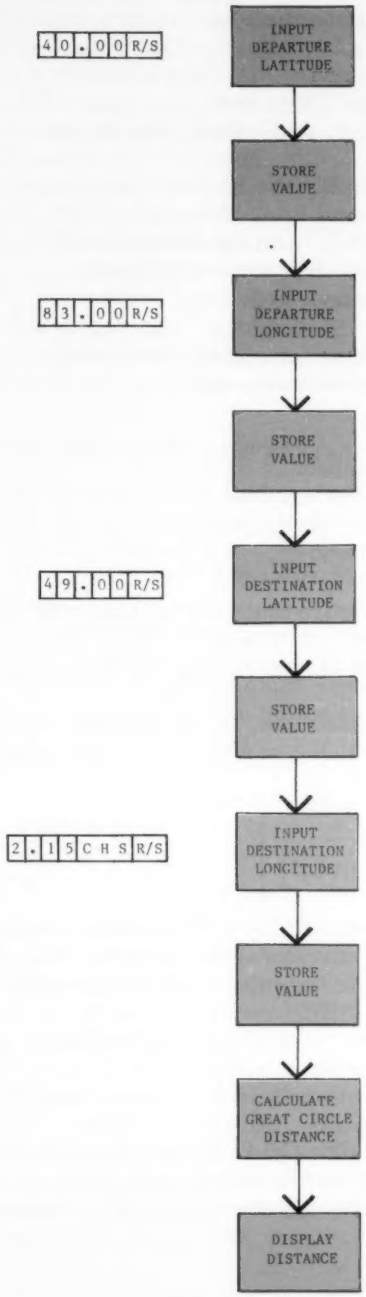


Figure 1

Great Circle Distance Computation

In this program (see Figure 1), the departure latitude is entered and stored. Followed by the departure longitude, input the destination latitude and destination longitude. The calculator then computes the great circle distance and displays the result. Note: the input values correspond to the first example given.

A more advanced example will string together the several programs necessary to accomplish flight planning.

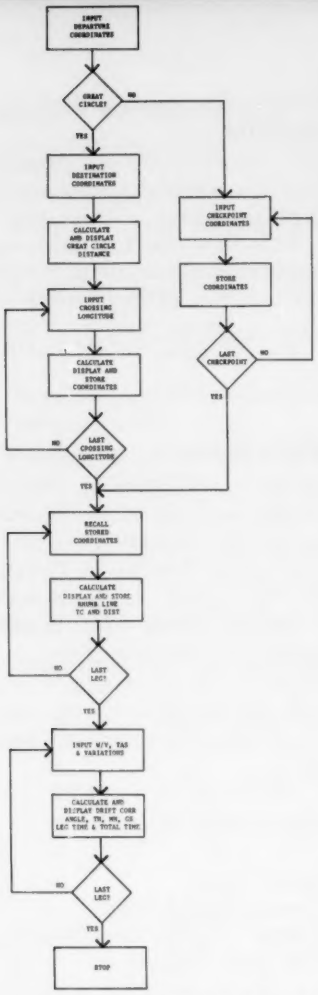
These programs consist of:

Great Circle
Canned Flight Plan
Rhumb Line TC and Distance
W/V and TAS

This collection of programs will be called "FLIGHT PLAN."

We will then ask, "Is this a great circle route (GC)? If the answer is "yes," the latitude and longitude of the destination will be requested, and the great circle distance will be calculated and displayed. Next, crossing longitudes will be requested and the corresponding latitude will be calculated. All coordinates will be stored for future use in Rhumb Line TC and Distance. If the answer to GC is "no," then the calculator calls the canned Flight Plan program and requests and stores the checkpoints in sequence. Rhumb Line TC and Distance is called next. This program recalls departure and checkpoint #1 coordinates from memory, calculates the Rhumb Line True Course and Distance for that leg, stores the TC and distance in the memory location occupied by the departure coordinates, and finally calculates the total distance. This sequence is repeated for each leg of the flight plan. W/V and TAS are entered for the first leg. Again, all legs are repeated until the entire flight plan is computed.

Figure 2



A detailed explanation of this program is:

1. Input departure coordinates.
2. Choose Great Circle or canned Flight Plan program.
3. If Great Circle is chosen:
   a. Input destination coordinates.
   b. Calculate and display Great Circle Distance.
   c. Input crossing longitudes; calculate and display corresponding latitude.
   d. Store coordinates.
   e. Repeat as necessary.
4. If canned Flight Plan is chosen:
   a. Input checkpoint coordinates.
   b. Store coordinates.
   c. Repeat as necessary.
5. Rhumb Line TC and Distance:
   a. Recall departure and first checkpoint coordinates.
   b. Calculate and display the Rhumb Line True Course, leg distance, and total distance.
   c. Store Rhumb Line TC and leg distance in the memory location of the departure coordinates.
   d. Repeat as necessary.
6. W/V and TAS:
   a. Input TAS, W/V, and variation for first leg.
   b. Calculate drift correction angle.
   c. Calculate TH.
   d. Calculate MH.
   e. Calculate groundspeed.
   f. Calculate and store leg time.
   g. Sum leg times for total time.
   h. Repeat as necessary.

This completes the flight planning portion of the program. Notice that each leg time was stored in 6f. These times can be used shortly after takeoff to complete the ETA column of the flight plan. Calculators can add hours, minutes, and seconds as easily as decimals and this is one place where I make frequent mistakes.

In the above flow charts, the diamond shaped events are decisions. In all previous examples, the decisions were made by the navigator. Now, let's discuss the calculator's ability to make decisions. For example, the formula to calculate the Rhumb Line True Course is:

$$TC = \tan^{-1}\left[\frac{\pi\,(Long_1 - Long_2)}{180\left[\text{Ln}\tan(45+\tfrac{1}{2}L_2)-\text{Ln}\tan(45+\tfrac{1}{2}L_1)\right]}\right]$$

Since the tangent function repeats itself every 180°, there is a possibility of calculating a reciprocal true course (075° instead of 255°). However, notice the term in the numerator of the equation, $Long_1$-$Long_2$. A test can be performed after the subtraction which would ask, "Is the calculated value negative? X40?" If true, add 180° to the calculated TC; if false, calculated TC = TC.

Similar tests could be performed for true courses less than zero. If true, add 360°; if false, calculated TC = TC.

Thus far I have been using flight planning examples. Now let's look at some possible in-flight applications of the programmable calculator.

Celestial precomps easily lend themselves to calculator use. The GHA of Aries can be calculated for any time by taking the hourly change, which is tabulated at the bottom side of each daily page in the Air Almanac, and applying it to the GHA of actual takeoff time. Thus, only one value need be entered into the calculator for the entire mission!

Star charts can be examined for applicable LHAs for the mission, and several stars can be chosen which will give the best LOP cuts. Their SHAs and Decs can be stored in the calculator for use later in flight. Let's look at a different approach which takes advantage of the additional precomp power of the programmable calculator.

Navigators using OMEGA describe a celestial precomp method which uses the great circle distance and true bearing between the observer's position and the subpoint of the celestial body *(see "OMEGA and INS Precomps" on p. 13).* This method could also be used by non-OMEGA equipped aircraft by using the Great Circle distance program described earlier. The observer's position would be entered as the departure point, and the subpoint of the body would correspond to the destination. A crossing longitude (one or two degrees toward the body's subpoint) would then be entered and its corresponding latitude calculated. The DR position and these last sets of coordinates would then be used with the Rhumb Line TC and Distance program to calculate the celestial body's Zn.

A second in-flight application for weapons system officers might be a program which converts UTM coordinates of an initial point (IP) and target to true bearing and distance in nautical miles from the IP to the target. After these values are computed, the calculator could be started over the IP and would then give "distance to go" to the target. It would perform repetitive calculations and display a new "distance to go" every one or two seconds!

This program would convert the IP-to-target distance in meters to nautical miles with an inserted groundspeed. When the R/S button was next pressed over the IP, the calculator would start to compute and display a "distance to go" in nautical miles. A typical program has accomplished one calculation in 1.2 sec. When the distance equaled six nautical miles, the displayed "distance to go" switched to "feet to go." Once the speed of the individual calculator is found and the correct K factor is applied to the calculation, extremely reliable results follow.

The previous examples demonstrate two important advantages: (1) the navigator is not constrained to traditional methods; and (2) new capabilities can be added without new equipment.

Features of an Ideal Navigational Programmable Calculator

Most of the features which I consider essential for an Air Force navigational programmable calculator already exist. However, some critical features need to be added:

1. An EMI/ECM shielded case. While present calculators (which use internal batteries and are not equipped with printers) will not cause electromagnetic interference with aircraft equipment, the reverse may not be true.
2. Multi-functional displays. I envision an alphanumeric capability for displaying at least 14 characters, fully legible in both day and night. In addition, a time of day, time to go, or elapsed time would be provided. Therefore, a built-in clock would be included.
3. Enlarged key buttons. These buttons would then be large enough for in-flight use with gloved hands.
4. Navigation subroutines. While most calculators work in degrees, radius, or grads, the direction system associated with maps must be built-in. I am referring to the difference between rectangular coordinate direction (0° at the 3 o'clock position increasing counterclockwise) and map coordinate direction (0° at the 12 o'clock position increasing clockwise).

Conclusion:

By now it is apparent that I have been describing something more than a calculator. The latest generation of programmable calculators is approaching the capabilities of small computers. Thus, a programmable calculator would become a personal device which navigators could program to suit their individual needs.

The examples in this article have not been tested in-flight and are therefore not recommended without further testing. In addition, the navigator cannot rely solely on such a device. The programmable calculator should be considered in the same light as radar or OMEGA: It is only an aid to navigation.

Lt Col Haloostock graduated from aviation cadets and navigation school in 1958, and spent 11 years as a C-130 troop carrier navigator. After Evreaux AB, France, he served stateside at Sewart AFB and Lockbourne AFB. In 1971, he received a BS degree in Electrical Engineering from AFIT, and then was assigned to the AC-130 in Southeast Asia. Lt Col Haloostock now is Chief Avionics Engineer, RECON/Strike SPO, Wright-Patterson AFB.

Last Flight

Lieutenant Colonel Edward B. BORDEN
HQ AFRES/PAI
Robins AFB, GA

2:49 p.m. "MAC 40613," says Jacksonville Center, "you're cleared to descend to Flight Level two-four-zero (24,000 feet)."

"Roger, 613 is descending to Flight Level two-four-zero."

In less than 40 minutes a 20-year flying career will end.

It was not a remarkable career except that its owner survived, occasionally performed great acts of derring-do, and served in the transitional period from crude aviation instruments of post-World War II America to the sleek, sophisticated avionics equipment of today.

What, then, do you say to a man—

...Whose 5,500-hour career finishes today?

...Who courted his wife, married, fathered four children, and saw the eldest finish high school—all within the span of navigator training school to career's end?

...Who saw his civilian career progress, after active duty service, from a news reporter on a small South Carolina daily to public relations director of a state agency with articles in national magazines?

...Who became involved in two major wars (Southeast Asia conflict and the Yom Kippur War of 1973) as an Air National Guardsman and Air Force Reservist?

I had been pondering these questions during this final day of a three-day Reserve trip to Ascension Island, and the answers escaped me. I didn't know what to tell him. For the man was myself.

"Crew, prepare for descent."

The Lockheed C-141 *Starlifter* cants nose downward. Charleston AFB, SC, lies some 80 miles away, embedded in a thick haze. Because of the winds, we ask for an ILS (Instrument Landing System) approach to Runway 33.

Five thousand, five hundred and fifteen hours. Where did it all go?

I wasn't a great navigator, Lord knows, but I was better than average because I was conscientious. I was conscientious because I knew my weaknesses. I wasn't about to let a plane get lost because of an oversight on my part. Though, on two occasions, I almost did.

2:52 p.m. "MAC 40613, descend to one-one thousand (11,000 feet). Altimeter 30.15."

"Roger, one-one thousand. Altimeter three-zero-one-five. Six-one-three."

Ahead in the gray dimness, the sun reflects off the water of Charleston Harbor.

"Charlietown dead ahead," says the copilot.

"Ayep," replies the aircraft commander.

It was my initial check ride in a KC-97, an old Boeing two-deck *Stratofreighter* that had been converted to an aerial tanker, and we were flying down the refueling track northwest of our home station, Dow AFB, Maine.

It was the easiest track to fly because it was studded with lakes. In my anxiety to have a

perfect rendezvous with a B-47, I gave the pilot too large a drift correction. When we finished refueling, I couldn't find the end-rendezvous point. We were 30 miles north of track, headed directly into Canada! I busted the check ride, even though everything else was perfect. It destroyed my confidence and I took six months to check out. But I learned the navigator's maxim: always dead reckon (use heading and groundspeed) to determine your approximate position.

A year or so later we were on an all-day search mission for a B-52 that went down in the North Atlantic 600 miles from shore. All of our navigation equipment, except the sextant, was unusable. At dusk we headed back to land. When we reached our estimated time of arrival at coast-in and no land was in sight, I panicked.

This time I used dead reckoning procedures, but wind information 24 hours old and a lack of fixing aids had caused our aircraft to drift 90 miles north of track! We coasted for another half-hour or so before we spotted land on the radar scope.

We made it to Dow safely with less than 20 minutes' fuel in the tanks. And I learned another lesson: never venture into uncharted areas (or waters) without at least two pieces of equipment to cross-check your position. It was a lesson that would prove invaluable in the future.

2:56 p.m. "40613, you're cleared to eight thousand, and for your ILS to Runway 33."

"Departing one-one thousand for 8,000. Cleared ILS, six-one-three."

Charleston looms ahead. Even in the haze we can make out the Cooper River Bridge and the Battery, at the far end of Charleston Harbor, where the Ashley and Cooper rivers meet.

We're busy for the next several moments with pre-landing checklists. My job is to monitor the approach, making sure the pilot stays on our assigned heading and altitude. I also follow our progress across a scaled map of the area, insuring the aircraft will clear all tall obstacles.

After four years of active duty at Dow, I became a reporter for the Rock Hill, SC, Evening Herald and joined the North Carolina Air National Guard, which was then transitioning into C-121 Lockheed *Constellations.*

The Strategic Air Command had trained me well. The Military Airlift Command (then the Military Air Transport Service) had navigation requirements that were much less rigid, so I checked out in record time.

You could go a whole hour and twenty minutes without getting a position! (It was 15 minutes in SAC.) There was only one problem. It wasn't fun and games anymore—flying over land and checking your position against your actual position on a two-hour leg. This was real. You could get a plane lost. And you'd be in it!

I was on a check ride to Southeast Asia. (We would take our 15 days of active duty in two segments. We'd spend five days going to Europe and six months later take 10 days to go to Japan or Vietnam and back.) The mission went from Travis AFB, CA (near Sacramento) to Hickam, and to Wake Island.

If you were going to Vietnam, you went to Guam, the Philippines and then, as they used to say, "in-country." If Japan was your goal, you'd go northwest from Wake, then direct.

They called it the "breakfast route" because the legs were 10-12 hours long and it seemed that wherever you landed you were eating breakfast! The legs from Travis to Hickam and from Hickam to Wake were the scariest because there was absolutely nothing around for you to go to if you got in trouble.

There was a low frequency radio station, *SFI,* (for navigation help between Travis and Hickam), and LORAN, a long range overwater navigation aid; but you often encountered weather interference and couldn't use them. That left nothing but the sextant and driftmeter.

Hickam to Wake was worse because you had only celestial to cross-check your groundspeed. On this particular mission everything had gone well and the standardization navigator had congratulated me on doing an exceptional job—that was two hours out of Wake.

An hour out, LORAN came in and we realized we were an hour behind our estimated time of arrival. The sun, on which we had depended for course line, did not give us any groundspeed information and I had the embarrassing duty of calling Wake Tower and telling them to revise our ETA. To make matters worse, my former squadron operations officer at Dow was just ahead and had no problems. It was a terrible, terrible night at the Drifter's Reef.

3:06 p.m. "MAC 40613, wind change. Active runway is now 22."

"Roger, we'll take a visual."

"Roger, 40613, descend to three thousand."

"Departing 8,000 for 3,000, six-one-three," replies the copilot.

Six-one-three is now a hub of activity as the pilots and flight engineer rush to finish the checklists before lowering the gear. Since the aircraft commander has accepted responsibility

for our altitude, I must ensure we don't violate any altitude restrictions.

Charleston Airport is now visible in the haze, some 15 miles away. We'll be landing on the short runway.

"MAC six-one-three," says Charleston Tower, "descend to one thousand, six hundred."

"Roger, one thousand, six hundred," says the copilot.

"Before landing checklist," says the aircraft commander.

"Landing gear warning horn cutout switch—normal," says the copilot.

"Landing gear—down, copilot."

"Down and centered, pilot," the aircraft commander adds.

A burbling roar, not unlike taking a shower beneath Niagara Falls, encases six-one-three. The plane bucks slightly at the buffeting winds on its extended landing gear. The runway is a gray ribbon on the horizon.

I had never flown on an overseas mission by myself until I came to Charleston in 1971 as a Reservist. Even the long missions to Southeast Asia were with an evaluator, instructor, or other navigators because our flying time in the Guard was limited. In the Associate-Reserve program, however, I really learned how to fly.

A year after I joined the unit, I was in Vietnam on a normal (for jets) five-day mission which extended to 15 days because we became involved in an exercise. The Reserve, like its active counterparts, used you because you were there. You had better know your business. (I did, but just barely.)

I volunteered for more and more missions—as many as I could get away with in my civilian work—but never went the northern route to Europe on what are called "NAT Tracks" (North Atlantic tracks) because of their close supervision by international monitoring agencies.

Thirty miles off course is out of tolerance and you came home downgraded to a student and embarrassed. I was determined that would never happen to me, so I didn't take the trips! Instead I took the easy ones to Guantanamo Bay, Puerto Rico, Panama, and South America.

I didn't take them, that is, until my conscience began bothering me. Finally, I signed up—not for a short trip on the NATs (four hours or so)—but a seven-hour leg across the southern part of the Atlantic from Norfolk NAS, VA, to Rota NAS, Spain.

Seven hours—and it was all mine. You can't believe how I sweated that one at night in my bed; often waking up in sheer terror at being violated for being off course. (I never dreamed past the violation. I always woke up.)

I was at Base Ops early and checked all the equipment. I knew the manuals. I knew what to do if certain equipment failed. I was eager—almost "hyper," as my daughters say.

To make a long story short, we checked in over our coast-in point, 10 degrees West, less than three miles off course. I had proved to myself that I belonged. Not long after that, I volunteered for a NAT and took four generals and their staff from the east coast to Germany, blocking in only 15 seconds off the estimate—enough for a nice fat letter of commendation.

The copilot says, "Spoiler handle-closed/disarmed. Spoiler Selector—Auto Land. Crew briefing."

"Completed," responds the aircraft commander.

"Brake pressure and release light—normal and on," says the copilot.

"No smoking switch."

"On," says the aircraft commander.

The airport is some eight miles away, about a thousand feet below. The trees have definition now and the cars move along the roads at toy-like speeds. The earth seems less real than the cockpit.

"Altimeters three-zero-one-five, copilot."
"Three-zero-one-five, navigator."
"Landing lights."
"On," replies the pilot.
"Navigator's report."
"Check completed."
"Engineer's report."
"Check completed."
"Cabin report."
"Secured," responds the loadmaster.
"Before landing check-completed."

And there it is. A career condensed into the last five or ten minutes. The gray ribbon widens and enlarges. Approach lights become distinct. The markings on the runway snap into sharpness.

What is there to say? Nothing. But I remember:

...Cold, frozen days in Maine when you couldn't touch the side of the aircraft with your bare hands because they would freeze to it.

...Pulling week-long alerts in SAC and the craziness that ensued: water bomb fights, playing poker, and racing model airplanes.

...The sweating concentration of a B-52 pilot, his eyes wide and white through his face mask as he jockeyed his bomber beneath our tanker.

...Cursing frozen and useless driftmeters and wondering when—if ever—the Air Force would get something better.

...My first sunset at altitude—a blazing glory of crimson colors radiating from a setting sun. And my first aurora borealis.

...Dropping to 1,500 feet on an off-airways mission over northern Canada, near the entrance to Hudson Bay, and watching the forests and hills and even the wildlife for hours on end.

...Shooting a star with my sextant in the C-124 over the South Pacific only to find it wasn't a star, but a satellite!

...Watching—again for hours—the gray-green endless waters of the Pacific; and finding, as you cross the atoll, you're "right on track."

...The wonderful people (especially children) in the Philippines, the Azores, Panama, Germany, Scotland, Iceland, Uruguay—all over.

...The frantic life in Iran, Saudi Arabia, Tokyo, and in Cebu City, Philippines.

...Thais—whole families of them—saluting our airplane and waving American flags as we deposit troops and cargo on a remote base in northern Thailand.

...The dismal waste of the Egyptian desert, and the sudden blossoming of the green strand that is the Nile. It is clear from the air why it's called "the birthplace of civilization."

...The bazaars in Jeddah, Saudi Arabia, and Tehran, Iran, with vast piles of merchandise, seemingly disorganized, and women and men bargaining like bees.

...An old man in Tehran carrying dozens of rugs on his back; and another doing the same task in La Paz, Bolivia.

...Israeli F-4s escorting us out to Lod Airport, hovering under each wing as if they were guardian angels. (We felt they were.)

...The Elburz Mountains near Tehran, rising with their snow-capped peaks in a setting sun, looking like so many layers of butterscotch and vanilla custard.

...Breakfast on cold, fall mornings at the Mildenhall Officers' Club; and an elderly woman in Prestwick, Scotland, whose photo I took and with whom my family and I now correspond.

...Laughter, fellowship and good times; sweat and anger and anxiety; lonely hours on a ramp in Sicily or Ohio or Guam. Wondering how your family's doing and if they miss you as much as you miss them.

...Shooting the stars on a cold, jet-black night at 35,000 feet, feeling their closeness and their mathematical certainty, and knowing there must be a God.

And so it goes. One thought spins others and the memory flows. We chock 613 in Baker-Two. I check the navigation computer, cut off the oxygen supply and unplug the headset.

Years of discipline have ingrained certain habits. Without conscious thought I find myself packing up the navigation kits and helping unload crew baggage from the aircraft.

Five thousand, five hundred and fifteen hours.

It isn't an end, but a beginning. A chance to be with my family; to enter another career field; to use my past experience and memories to solve new problems.

It isn't an end...but it still hurts like hell.

I climb into the crew bus without looking back.

Lt Col Borden completed navigator training in 1959 and was then assigned to the KC-97 at Dow AFB. After leaving active duty, in 1963 he became a navigator with the North Carolina ANG flying the C-121 and then the C-124. In 1971, he transferred to the Reserve C-141 Associate Program, Charleston AFB. Col Borden now is assigned to the Public Affairs Office, HQ AFRES, Robins AFB.

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